PRECISE
Pathway Rendered Experimental Concepts
for InSITE SVS Experiment
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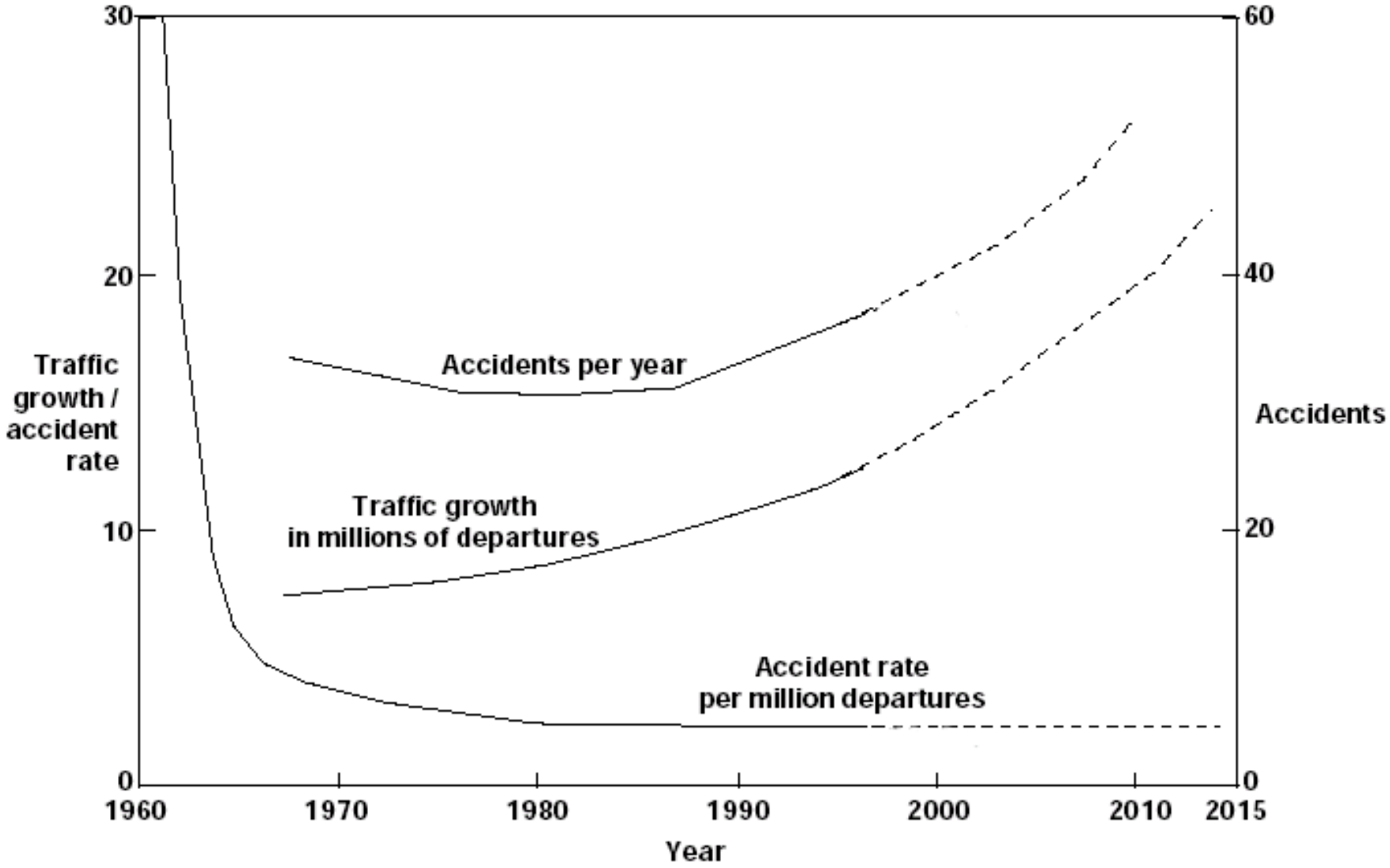
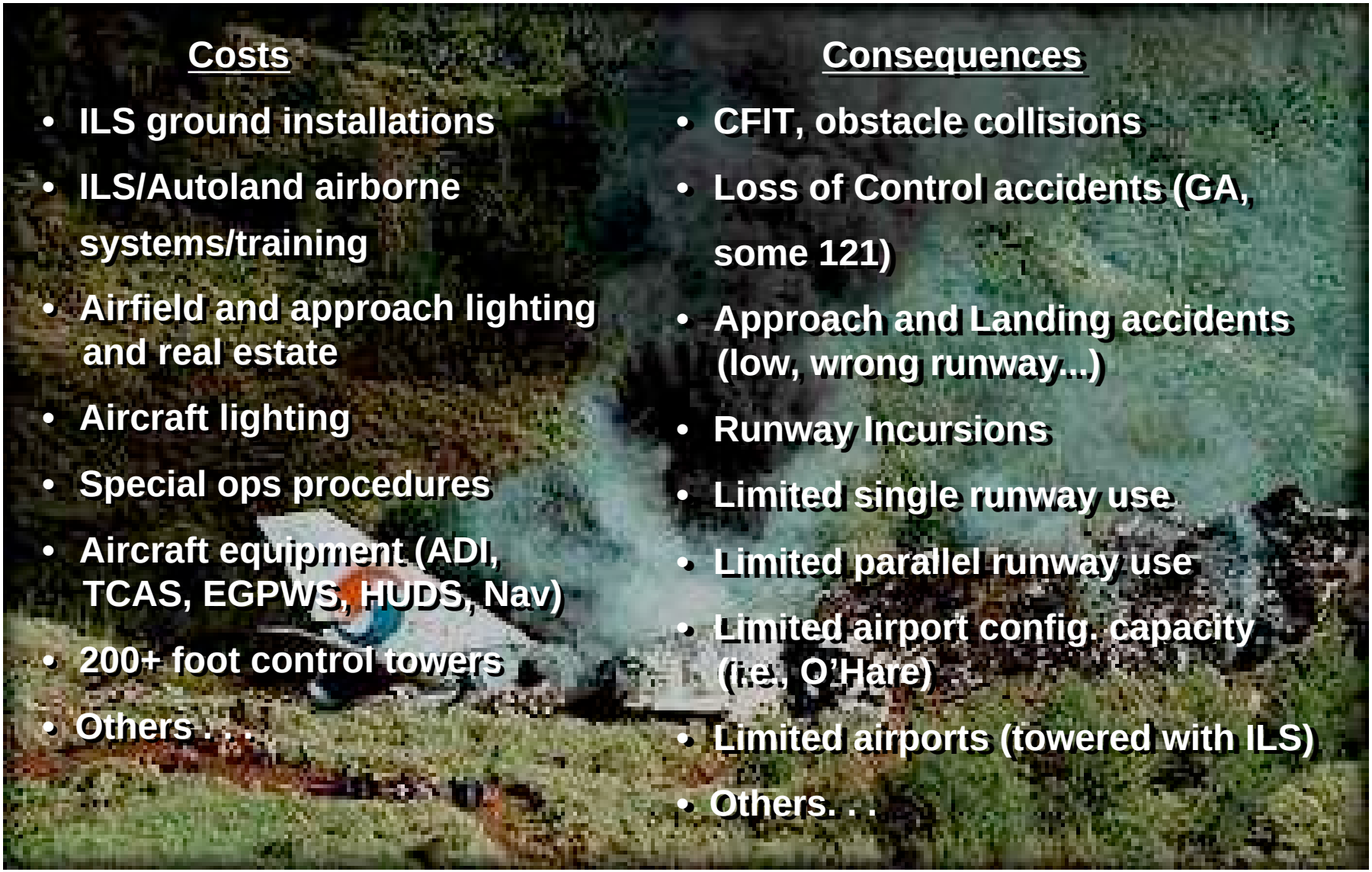
NASA Langley Research Center

Aviation Accident Trend



What the Need for Visibility Makes us Do



Costs

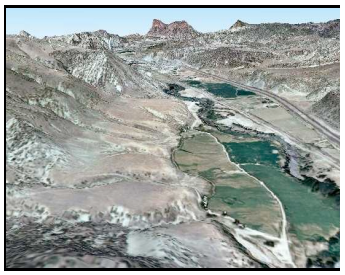
- ILS ground installations
- ILS/Autoland airborne systems/training
- Airfield and approach lighting and real estate
- Aircraft lighting
- Special ops procedures
- Aircraft equipment (ADI, TCAS, EGPWS, HUDS, Nav)
- 200+ foot control towers
- Others . . .

Consequences

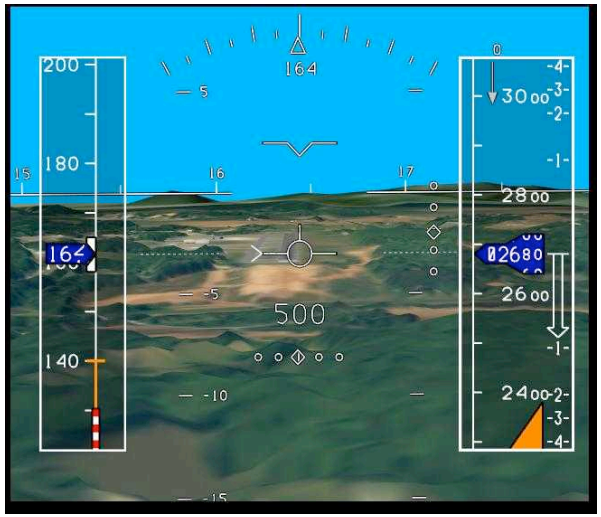
- CFIT, obstacle collisions
- Loss of Control accidents (GA, some 121)
- Approach and Landing accidents (low, wrong runway...)
- Runway Incursions
- Limited single runway use
- Limited parallel runway use
- Limited airport config. capacity (i.e., O'Hare)
- Limited airports (towered with ILS)
- Others. . .

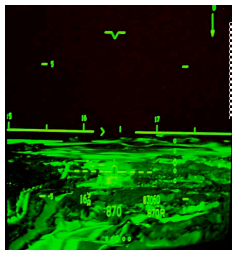
The Complete Solution: Synthetic Vision

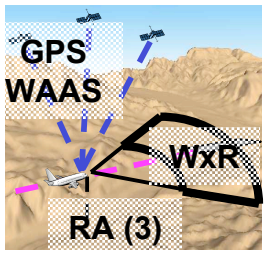
A **database derived system** utilizing precise GPS navigation & integrity-monitoring sensors (as required) to provide a **unrestricted synthetic view** of the aircraft's current external environment, regardless of weather or time of day



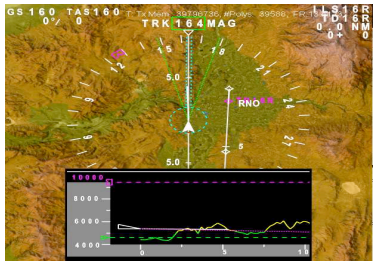
Worldwide Terrain & Obstacle Database







Advanced Sensors for Database Integrity & Object Detection



Real-Time Integrated Hazards Displays

Traffic Information & Surface Guidance

Future Commercial Cockpit

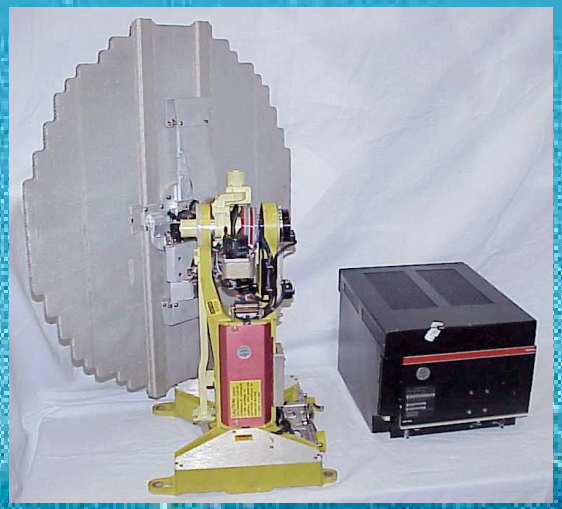
Benefits of Synthetic Vision for Aviation

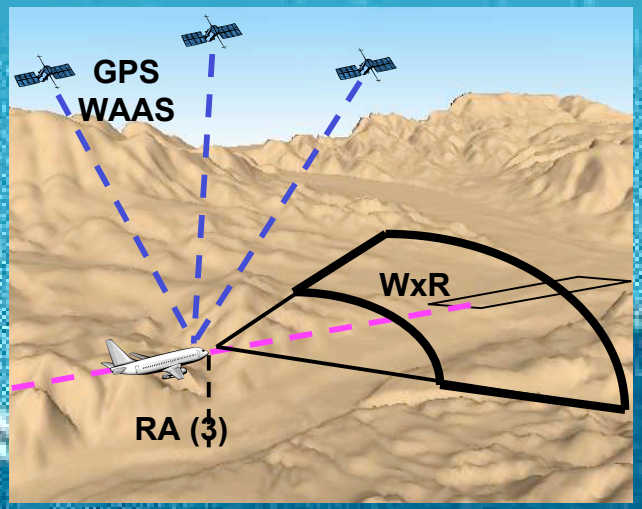
- Cost-benefit analyses predict $780 million dollar savings per year with synthetic vision technology with investment of 110K per aircraft
- Research has demonstrated operational benefits of synthetic vision and enhanced situation awareness for approaches to operationally complex and terrain challenged airports (Prinzel et al., 1999, 2000, 2001, 2002, 2003, Kramer et al., 2003).
- In addition to operational and economic benefits, there are significant aviation safety benefits. NASA research has demonstrated the efficacy of synthetic vision to mitigate spatial disorientation, CFIT, and runway incursions.
- A substantial amount of human factors research has also been conducted to help ensure a “human-centered” synthetic vision system

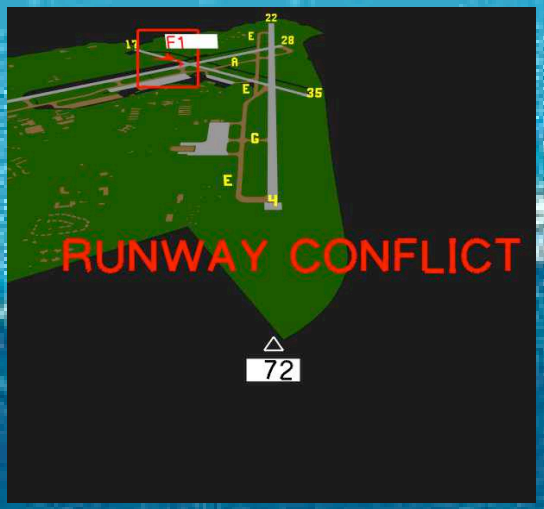
NASA Synthetic Vision Flight Test at Eagle Vail, Colorado Airport

NASA Synthetic Vision Night Flight Test at Dallas-Fort Worth Airport

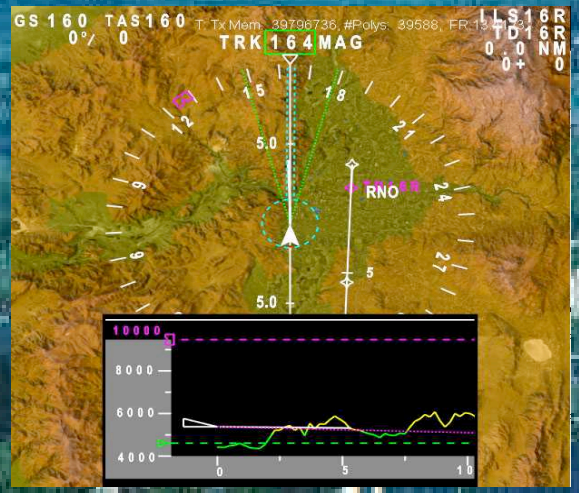
NASA Synthetic Vision GA Flight Test at Roanoke, VA Airport

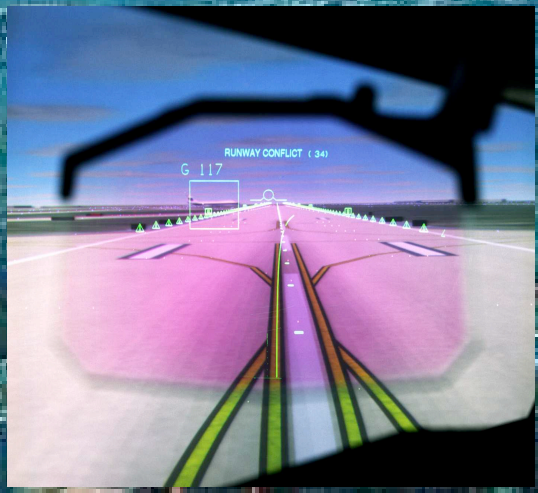






INitial SVS Integrated Technology Evaluation

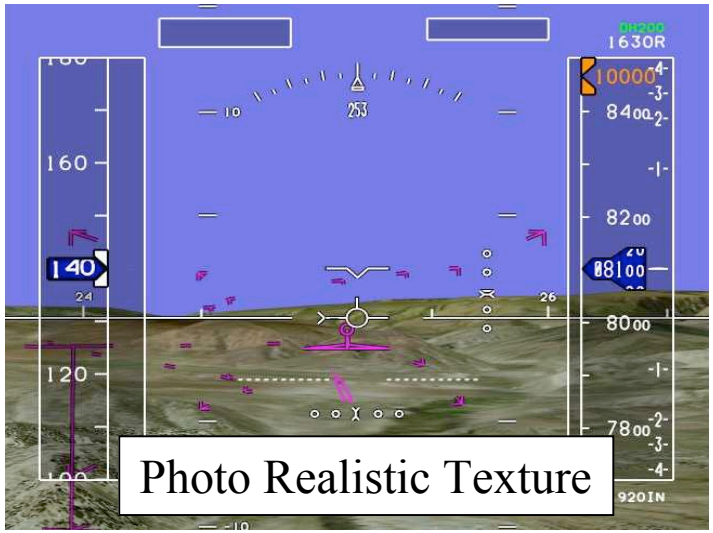


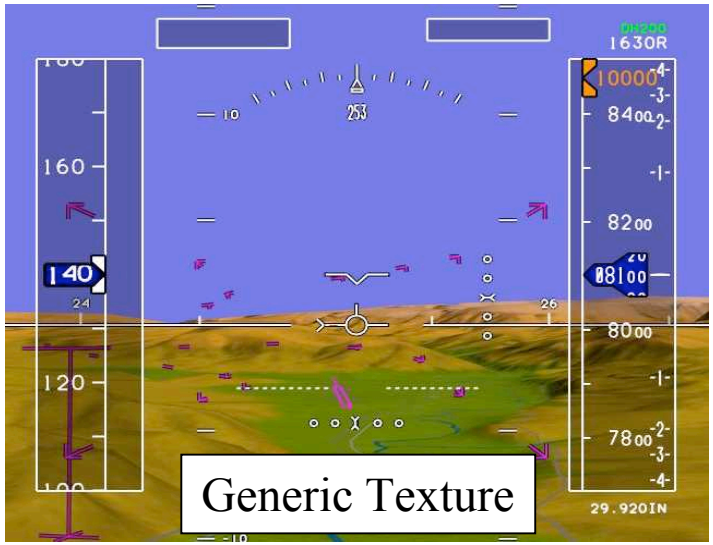


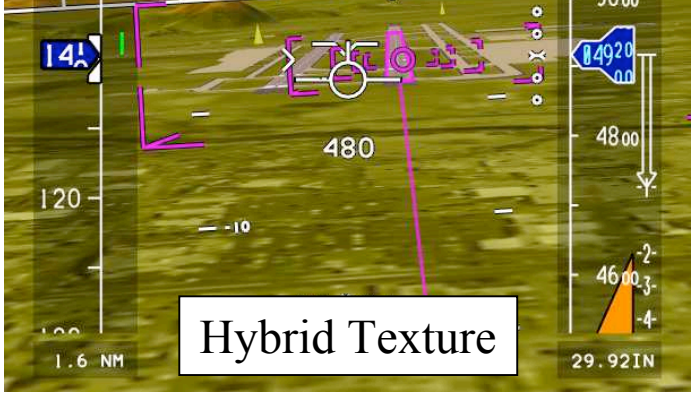
Experimental Objectives

- Evaluate four pathway / tunnel concepts
- Evaluate three guidance symbology presentations
- Evaluate concepts for visual approach under IMC
- Compare pathway and guidance concepts to baseline concept

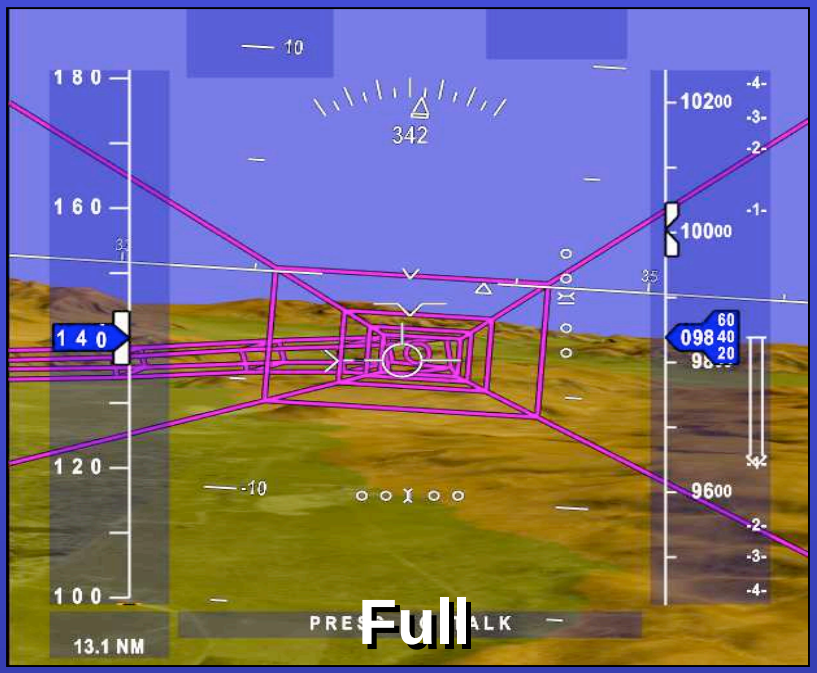
Synthetic Vision Hybrid Texture Concept







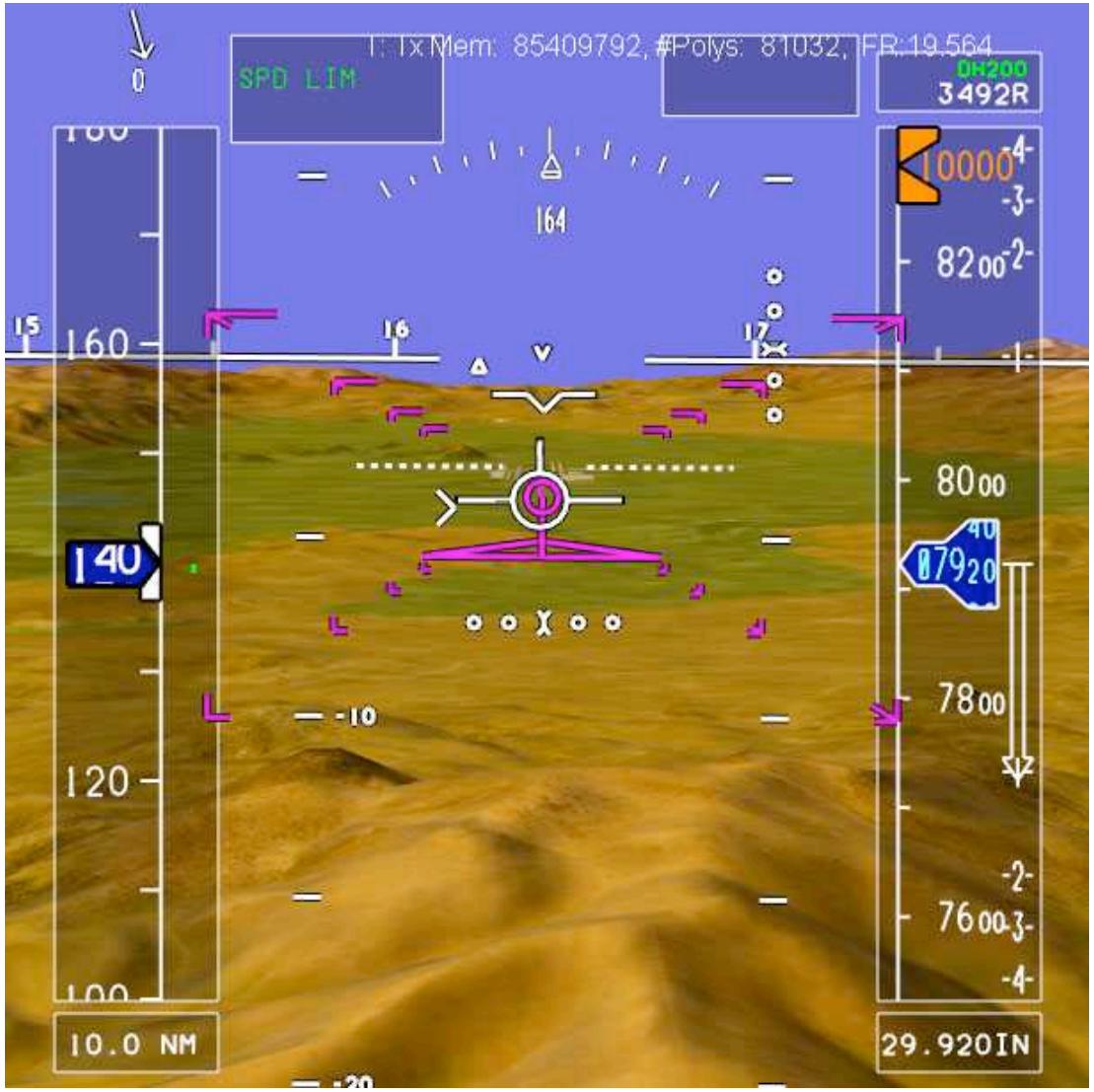
Minimal


Full

Dynamic Pathway

Dynamic “Crows Feet”

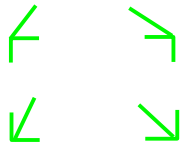
Dynamic Tunnel Concept



Dynamic tunnel concept:

- Minimize Display Clutter When on Path
- Provide Enough Information to Reacquire Path When off Path

Tunnel Corners
every .2 NM



1 dot wide (+/- _)
2 dots high (+/- 1)

Max 600' Wide
Max 350' Tall
Min 50' Tall

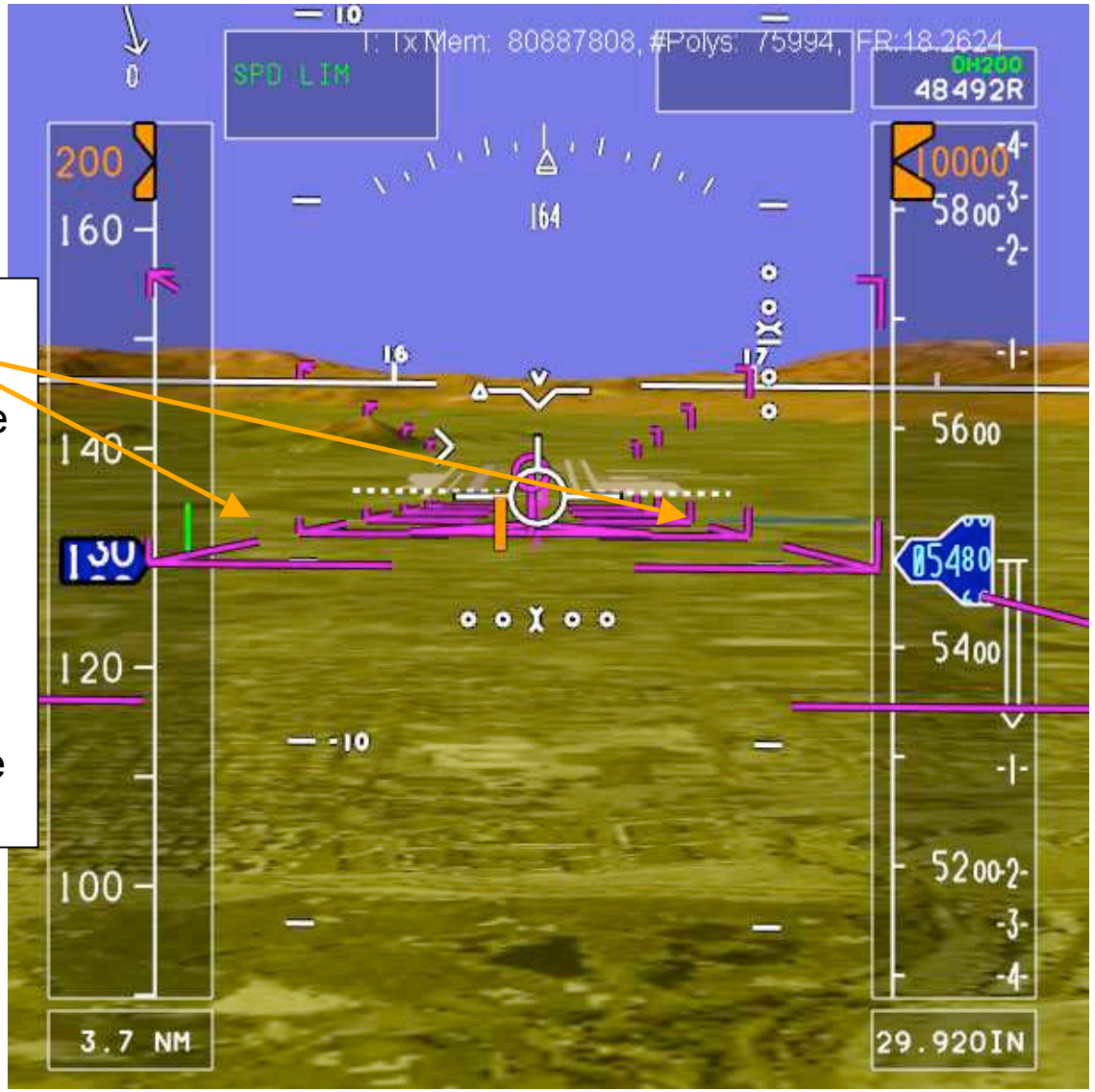
Notes: Fading and Number of Visible Tunnel Segments Experimentally Varied

Dynamic Tunnel Concept

Path Deviation

- Tunnel corner lines lengthen in direction of deviation to indicate you're approaching tunnel edge.

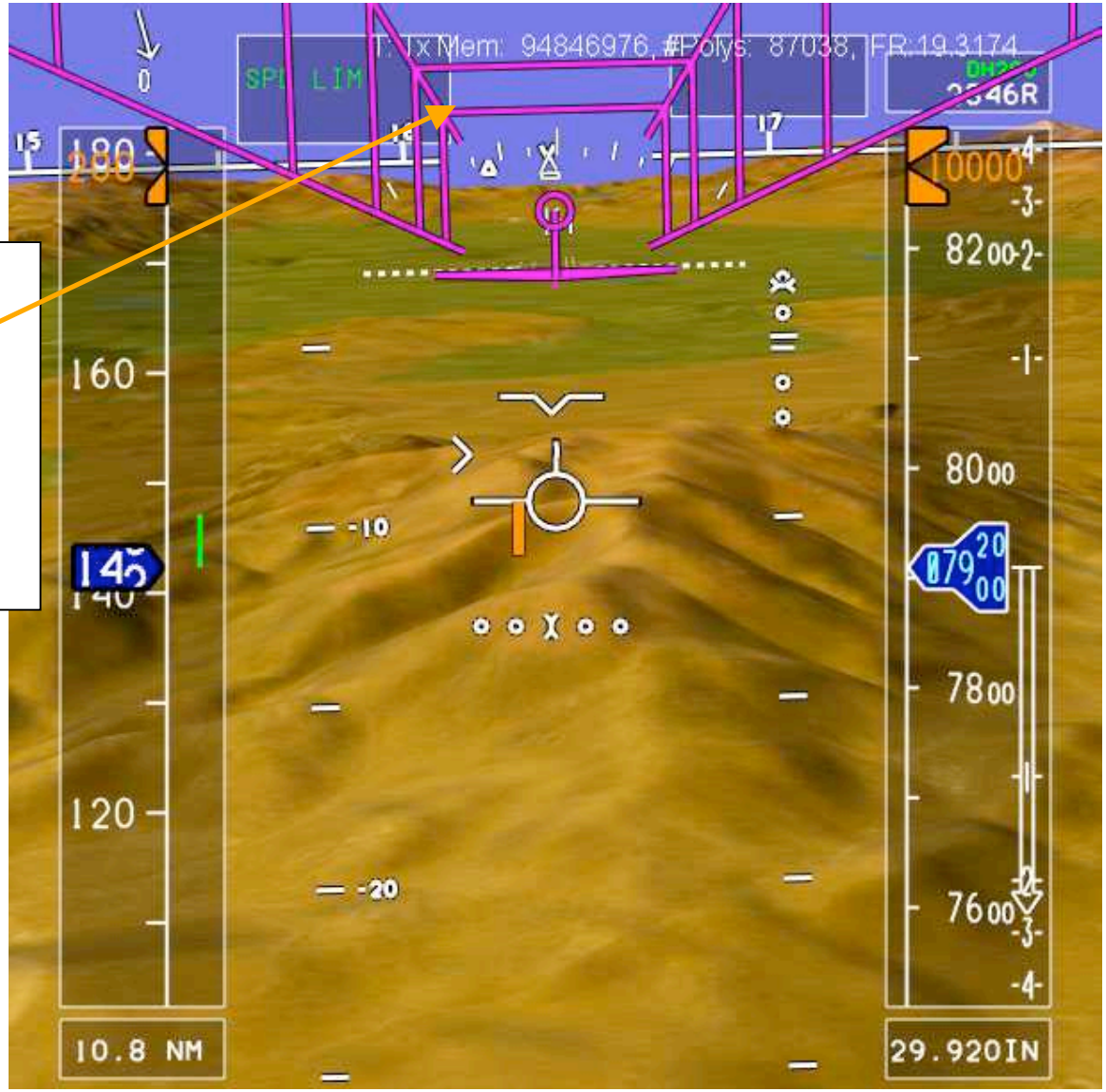
- In this example, flight path marker is moving toward bottom of tunnel so those corner lines are lengthening. Once the flight path marker is at the tunnel bottom, there will be a solid line between the two tunnel corners.



Dynamic Tunnel Concept

Outside tunnel
- Fly into “trough” to reacquire path.

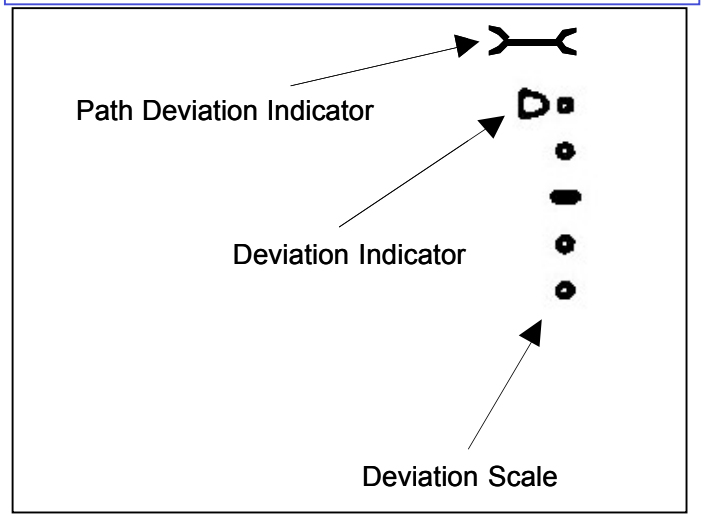
- In this example, flight path marker is below tunnel so the pilot should fly up into the tunnel opening to get back on path.

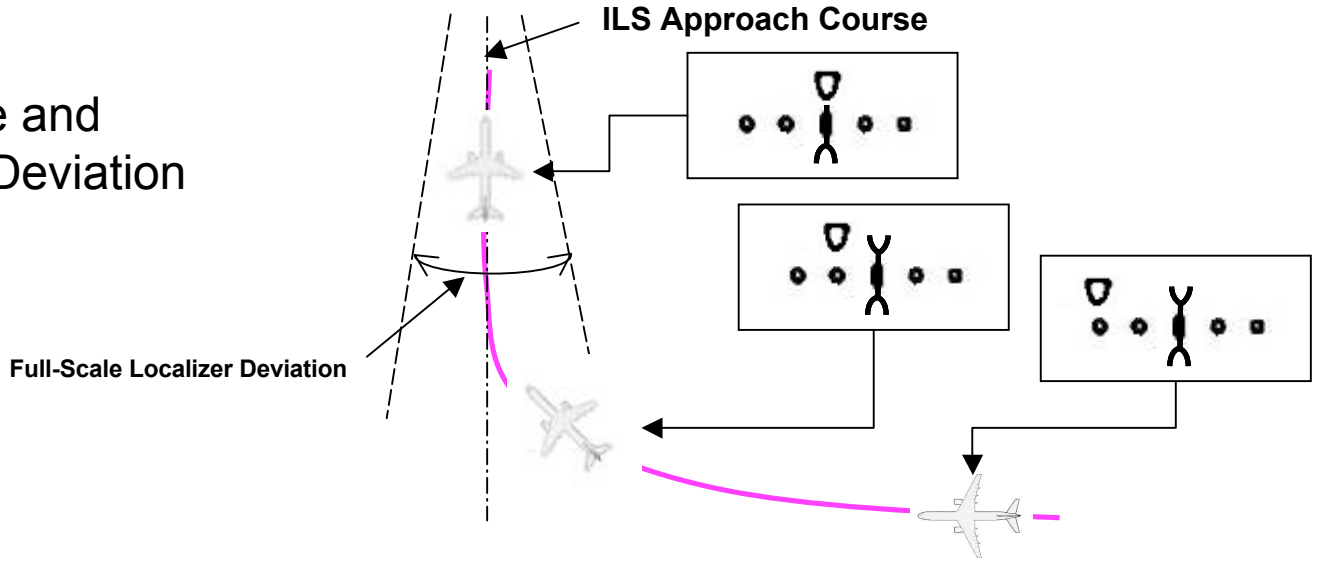


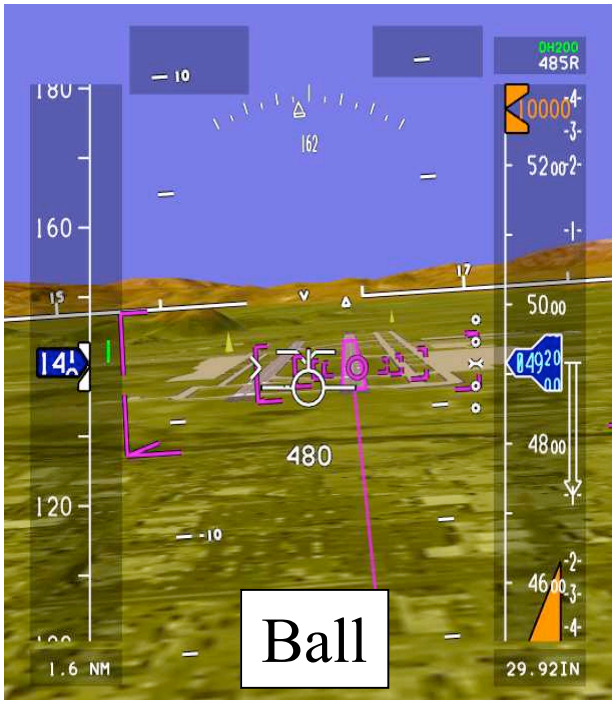
Path Deviation Indicators

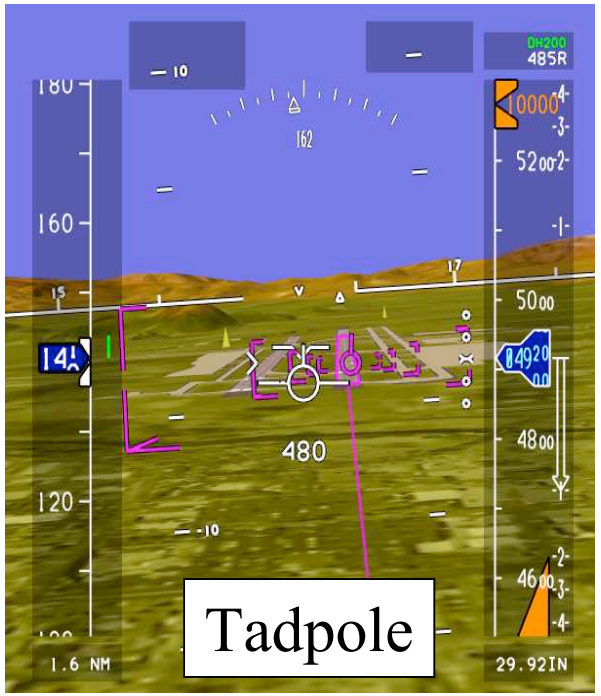
- Vertical and Lateral Deviation Raw Data Indicators
  - Deviation Scale
    - Center, +/- 2 Dots
  - Path Deviation Indicator
    - “Dogbones”
  - Angular Deviation Indicator
    - Glideslope and Localizer Deviation

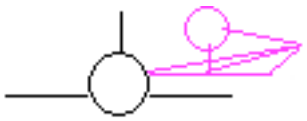
Vertical Deviation Raw Data Example



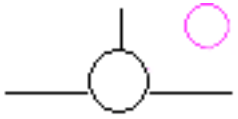




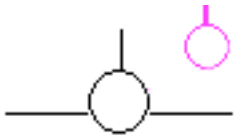




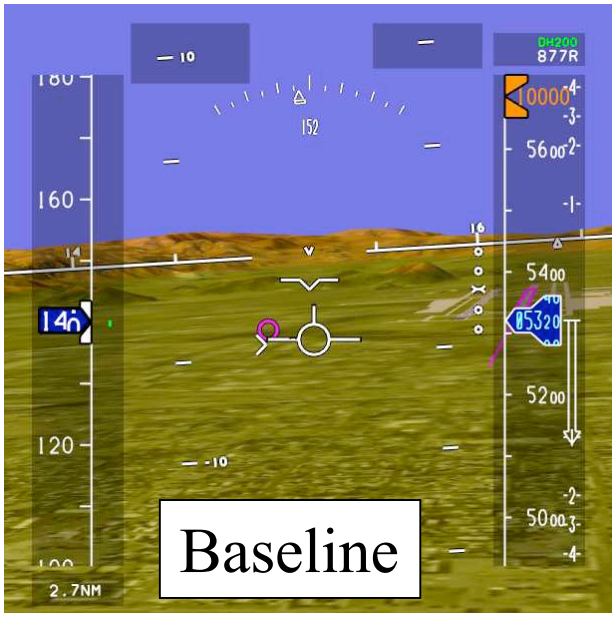
Ghost

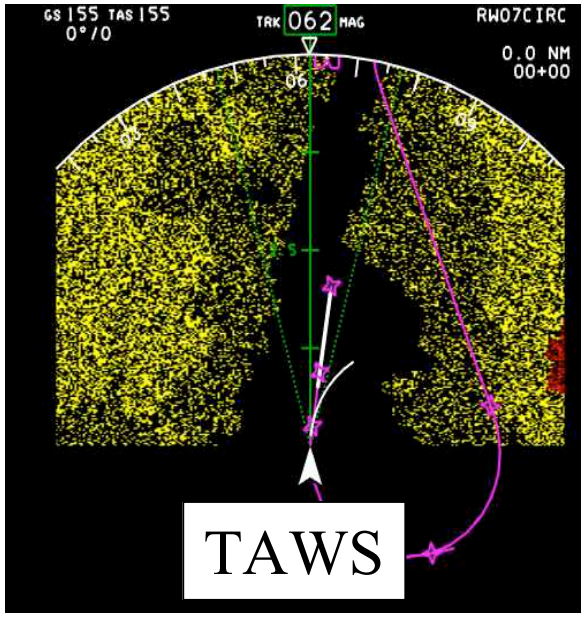


Ball



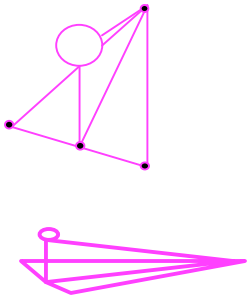
Tadpole





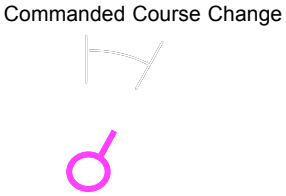
Guidance Symbology Concepts

Ghost Aircraft
(Pursuit Guidance)



- Aircraft Stick Figure, Drawn with 3D Perspective, nominally 15 Seconds Ahead of Own-Ship
- Provides Pitch and Roll Command to Tunnel Center
- Flys Down Center of Turn, Except in Turns

Tadpole
(Pursuit Guidance)

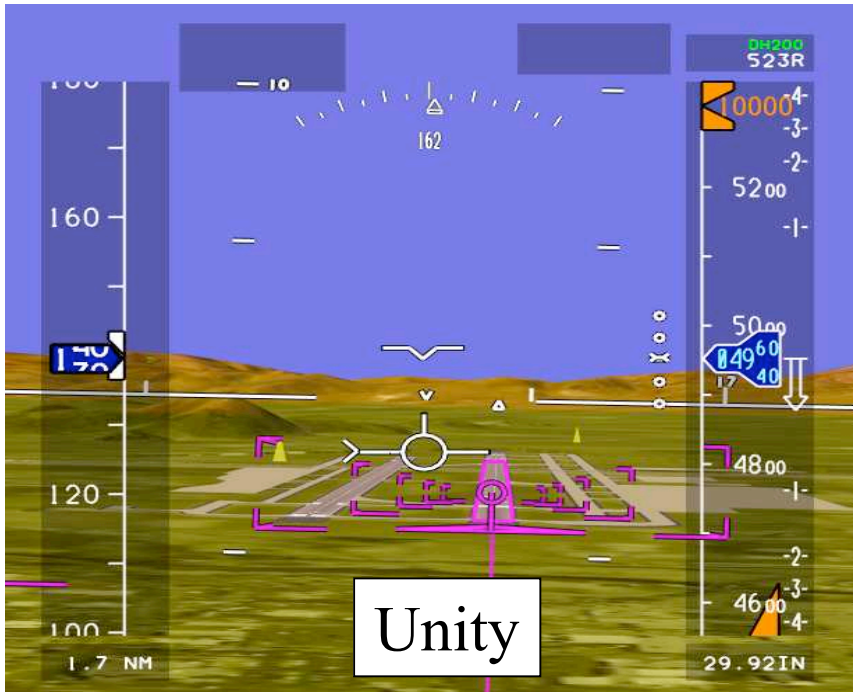


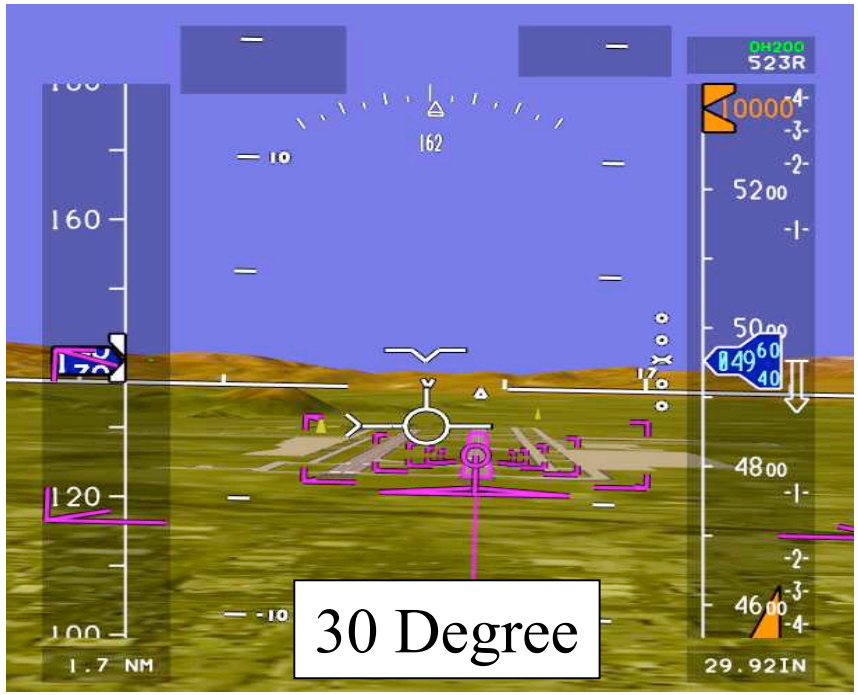
- Uses Same Pursuit Guidance Method as Ghost Aircraft without 3D Aircraft Stick Figure
- Flys Down Center of Turn, Except in Turns
- Tadpole Angle Shows Direction of Commanded Turns

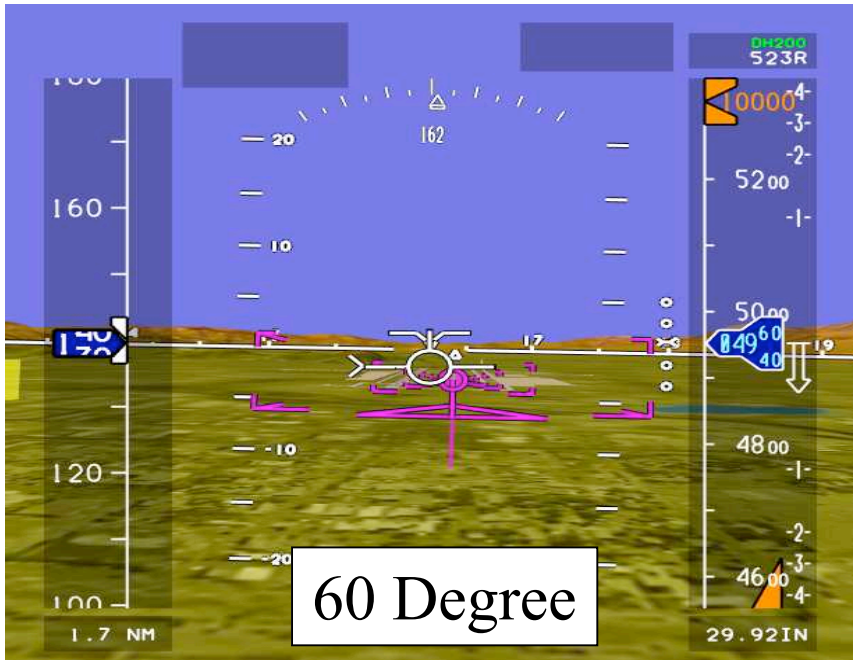
Ball

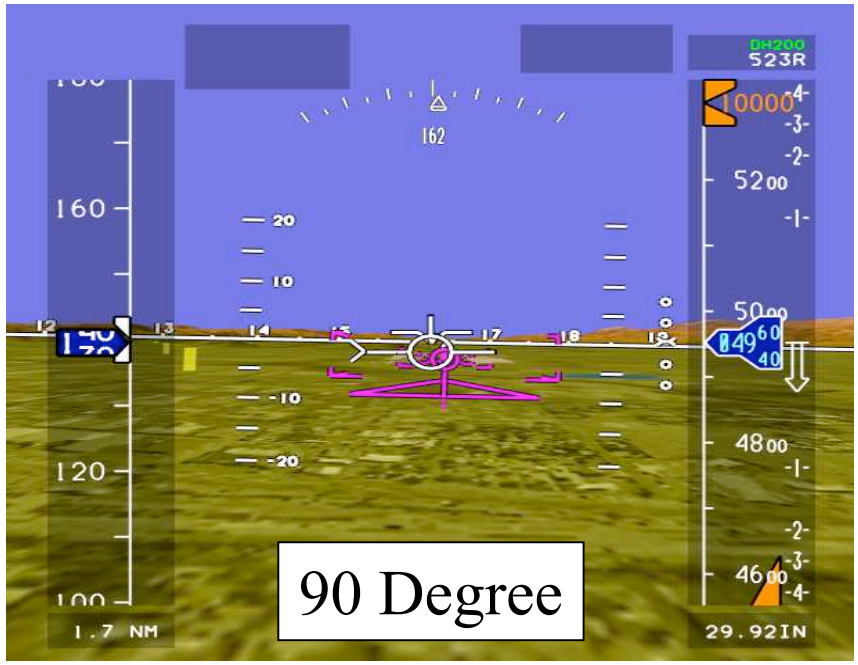
(pursuit guidance)

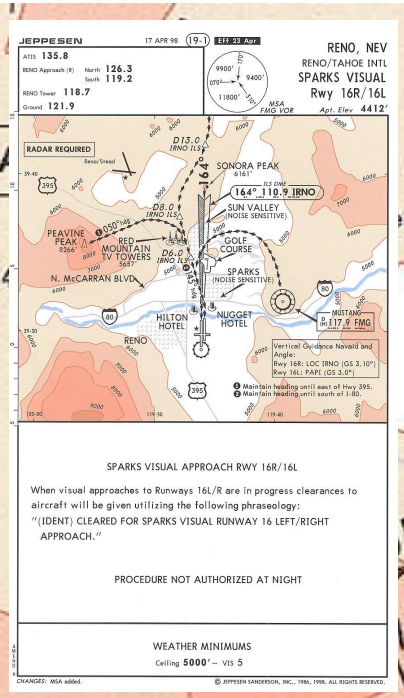
- Same as Ghost and Tadpole


Unity
1.7 NM
29.92IN


30 Degree
1.7 NM
29.92IN


60 Degree
1.7 NM
29.92IN


90 Degree
1.7 NM
29.92IN



D13.0 IRNO ILS

164°

SONORA PEAK 6161'

ILS DME 164° 110.9 IRNO

SUN VALLEY (NOISE SENSITIVE)

D8.0 IRNO ILS

050° hdg

RED MOUNTAIN TV TOWERS 5657'

GOLF COURSE

MC RAN

D6.0 IRNO ILS

KNB16

SPARKS (NOISE SENSITIVE)

145° hdg

N. McCARRAN BLVD

HILTON HOTEL

NUGGET HOTEL

MUSTANG D (H) 117.9 FMG

RENO

1 Direct to MCRAN. Descend and maintain 6200 MSL. Cross at or above 6200

2 Turn L heading 243
4823 RA
5-6° pitch descend
2000 fpm at 140 knots

3 Cleared for approach
To 16R ILS Freq 110.90

4 Re-enter Tunnel

5 End Run @ 200 AGL

Vertical Guidance Navaid and Angle:
Rwy 16R: LOC IRNO (GS 3.10°)
Rwy 16L: PAPI (GS 3.0°)

❶ Maintain heading until east of Hwy 395.
❷ Maintain heading until south of I-80.

120-00 119-50 119-40

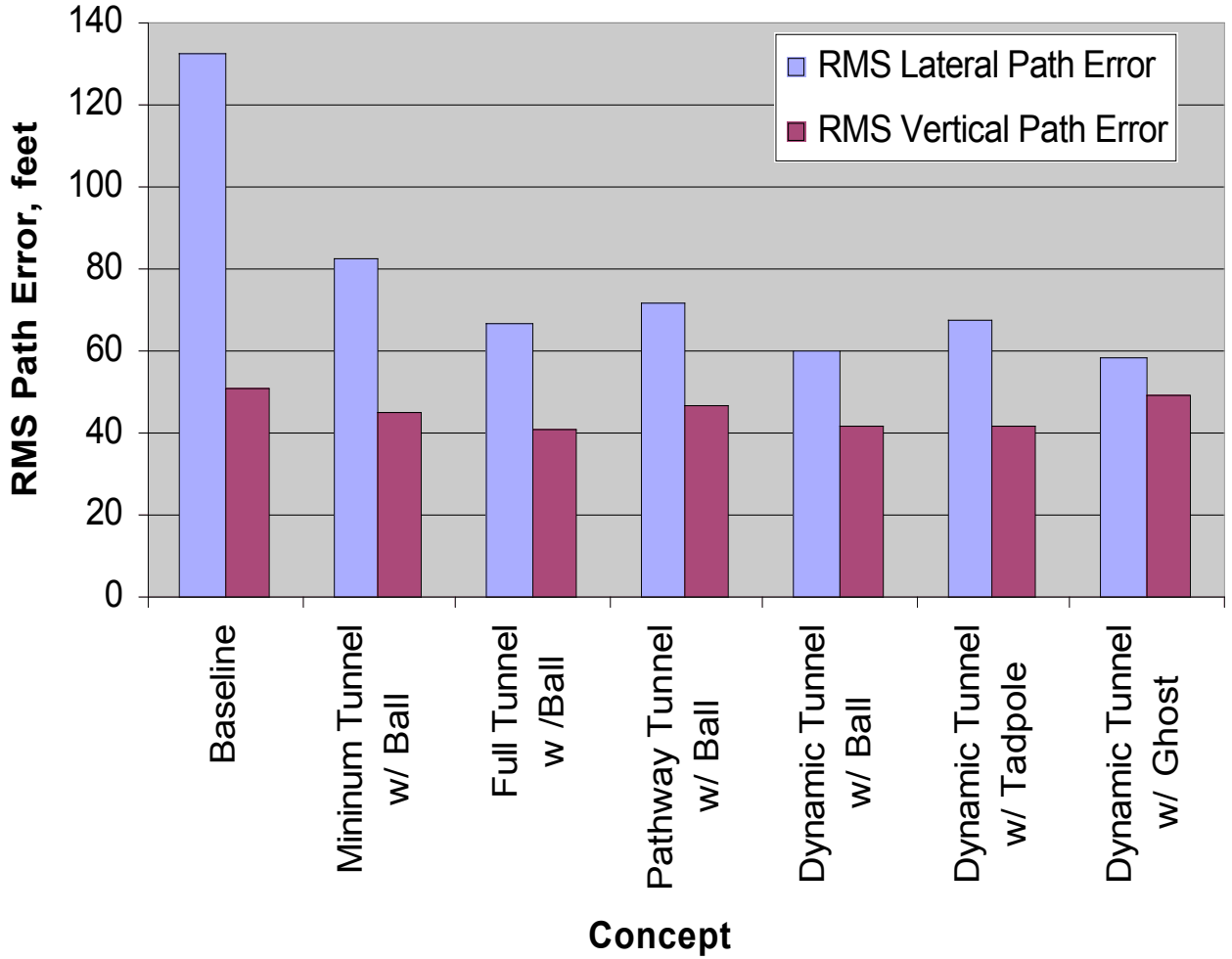
Tunnel Concepts During Sparks 16R Approach

Dynamic Tunnel
&
Ghost Symbology

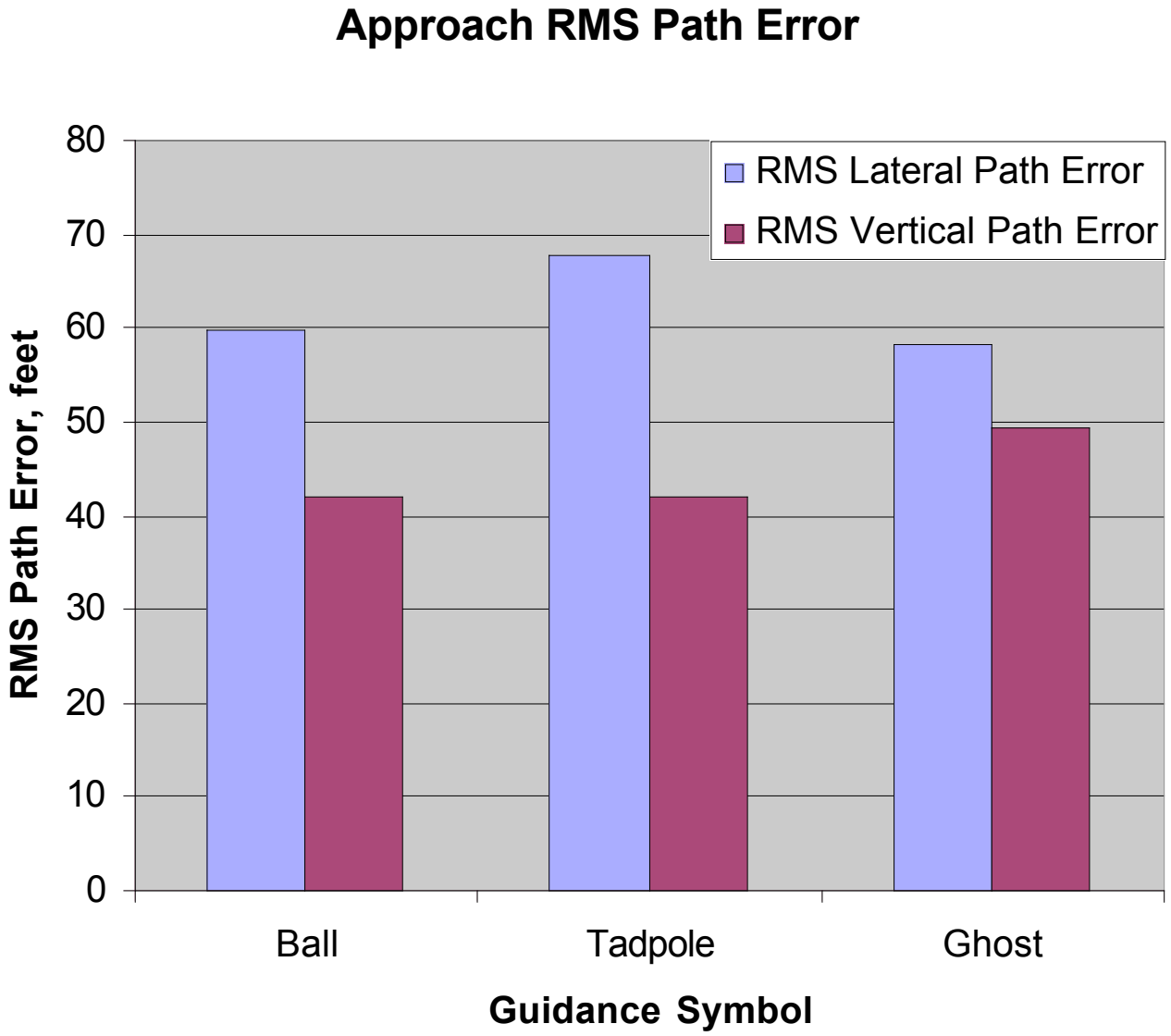
NASA
JEPPESEN
OHIO UNIVERSITY
BAE SYSTEMS
RANNOCH
USAF
ROCKWELL COLLINS
Aviation Safety Program
SVS
Synthetic Vision Systems
NASA
PRECISE
Performance Results

Tunnel Concept RMS Error

Approach RMS Path Error



Guidance Concept RMS Error



NASA
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OHIO UNIVERSITY
BAE SYSTEMS
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Aviation Safety Program
SVS
Synthetic Vision Systems
NASA
PRECISE
Run Questionnaire Results

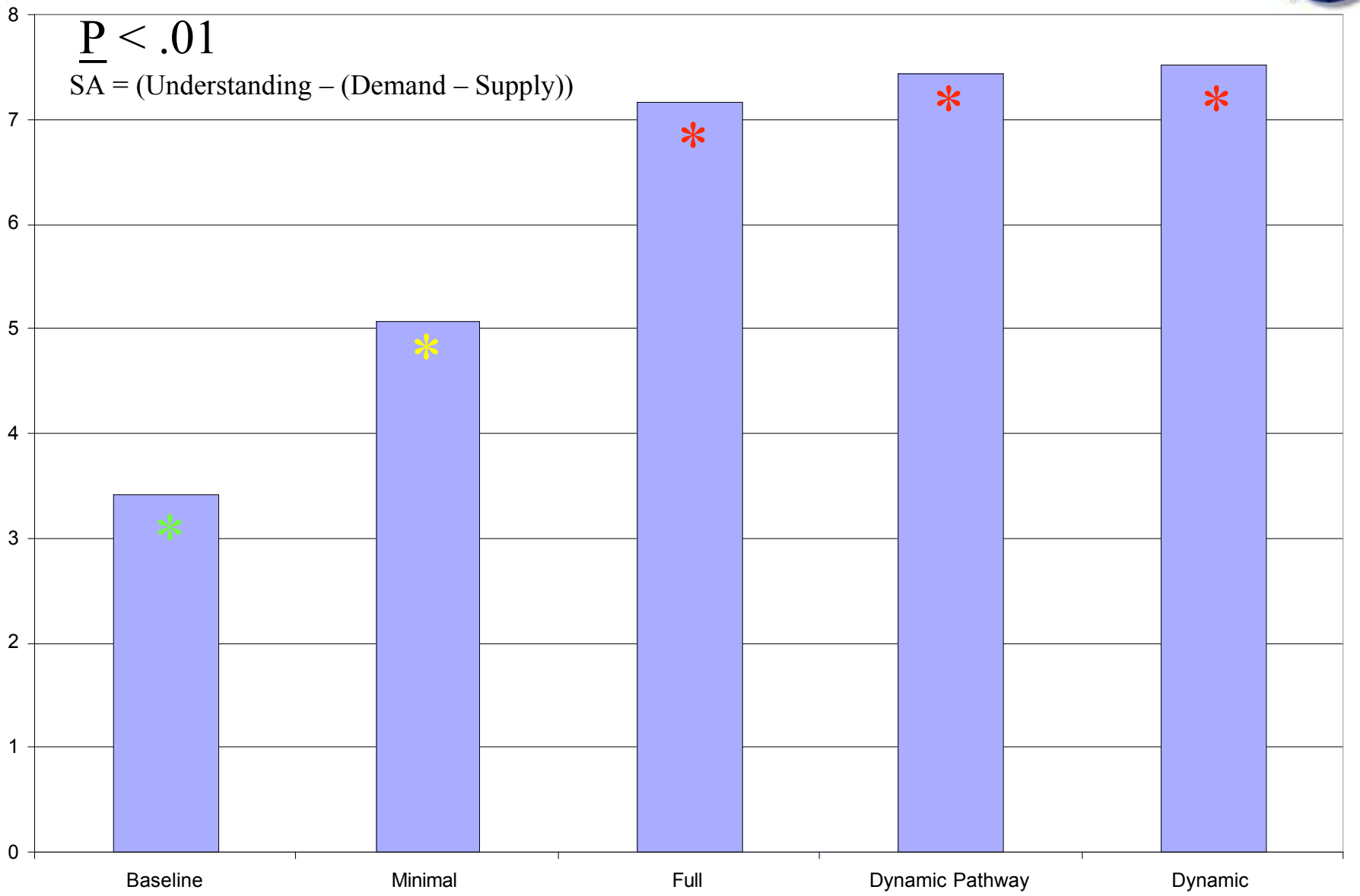
Post-Run Questionnaires

	Workload Estimate
1	Nothing To Do; No System Demands
2	Light Activity; Minimum Demands
3	Moderate Activity - Easily Managed; Considerable Spare Time
4	Busy - Challenging but Manageable; Adequate Time Available
5	Very Busy - Demanding To Manage; Adequate Time Available
6	Extremely Busy - Very Difficult; Non-Essential Tasks Postponed
7	Overloaded - System Unmanageable; Essential Tasks Undone; Unsafe

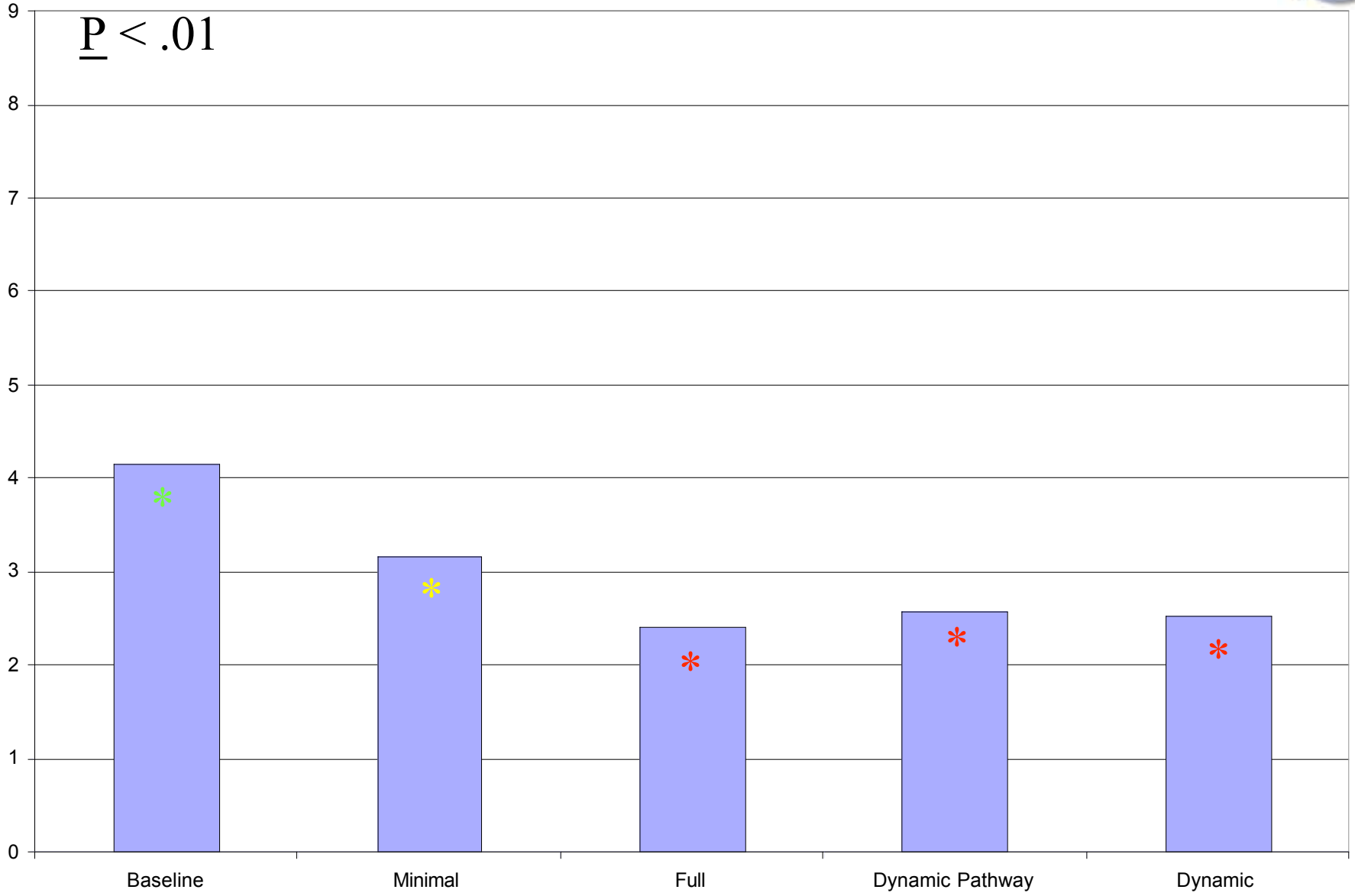
Situation Awareness Ratings	Low ..... High						
	1	2	3	4	5	6	7
SART #1 - Demand on Attentional Resources: How Much Demand Was Placed On Attention Due To Complexity And Variability Of The Task?							
SART #2 - Supply of Attentional Resources: How Much Spare Attention And Mental Ability Was Available To Accomplish The Task?							
SART #3 - Understanding: What Was The Level Of Understanding Of Information And Familiarity Of The Situation?							

Post-Run Questions	Low ..... High						
	1	2	3	4	5	6	7
Q. 1: As I Performed The Task, My Awareness Of Where I Was In The Tunnel Was _____.							
Q. 2: As I Performed The Task, My Awareness Of Upcoming Turns Using the Tunnel Was _____.							
Q. 3: As I Performed The Task, My Level Of Flight Path Control And Performance Was _____.							
Q. 4: As I Performed the Task, My Ability to Intercept the Path and Re-Enter the Tunnel Was _____.							
Q. 5: As I Performed the Task, My Ability to Anticipate Flight Path Changes Using the Guidance Symbol Was _____.							
Q. 6: As I Performed The Task, My Awareness of Terrain Features and Obstacles Was _____.							

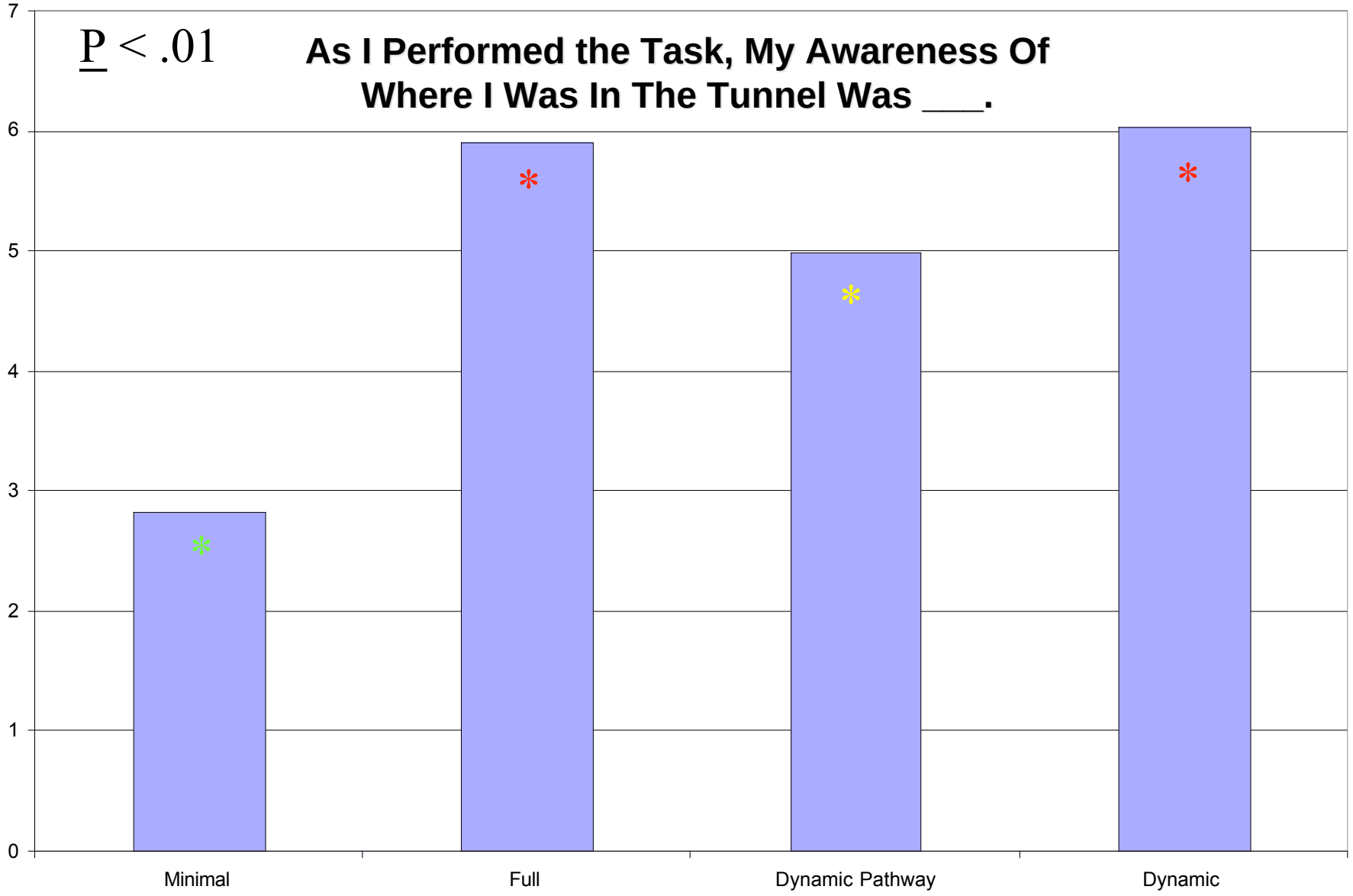
SART Ratings



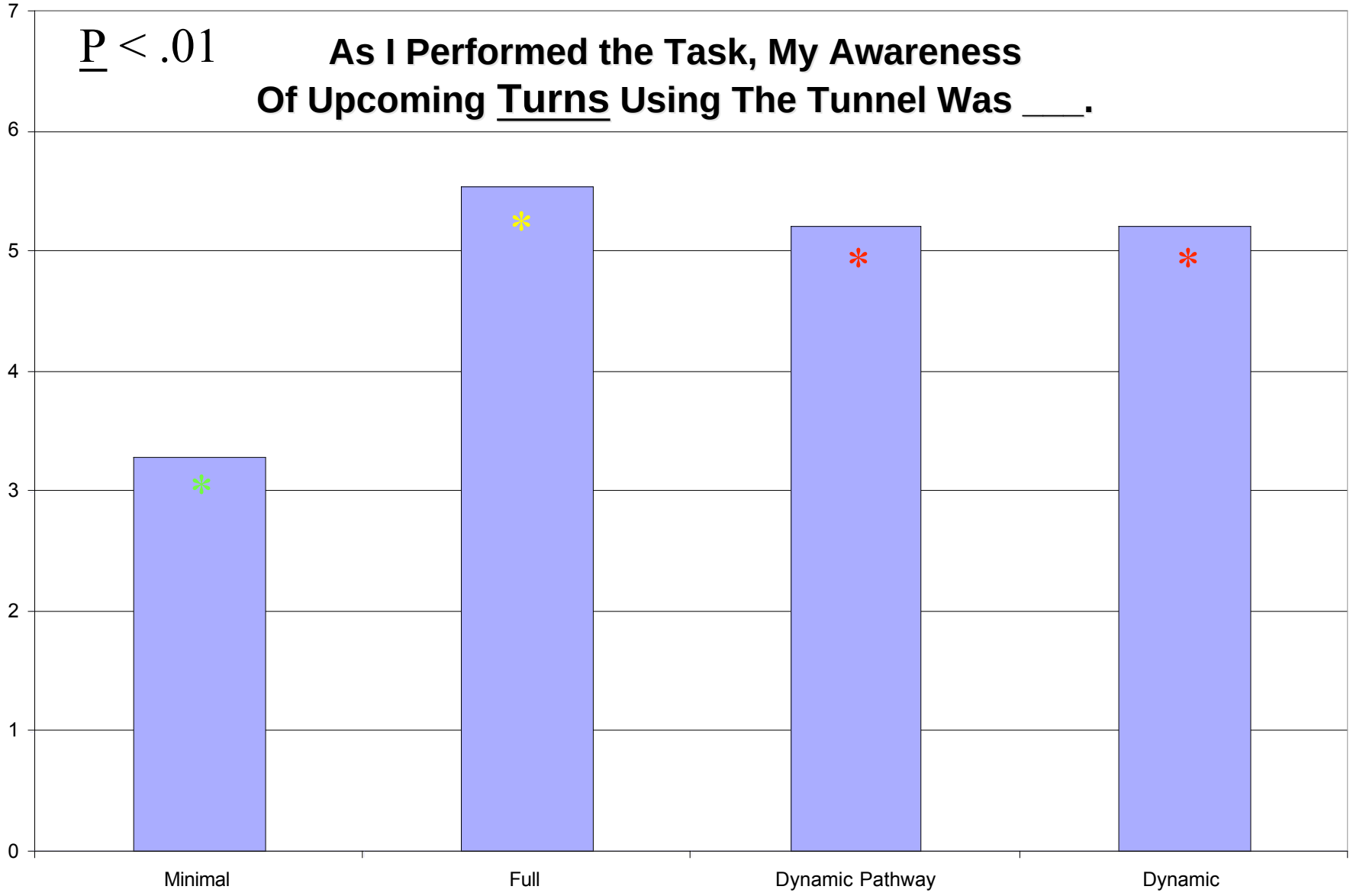
Mental Workload Ratings



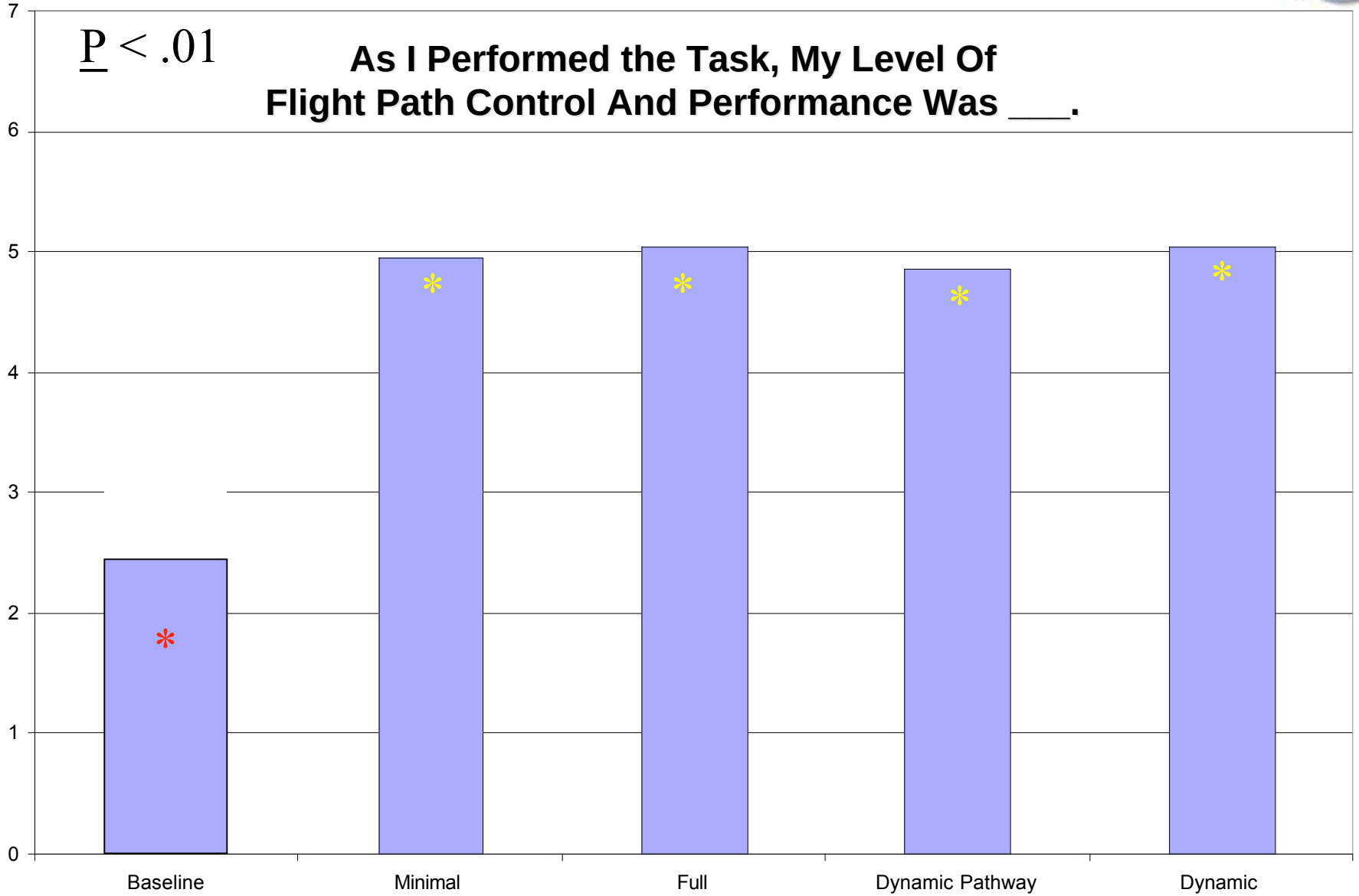
Post-Run Question



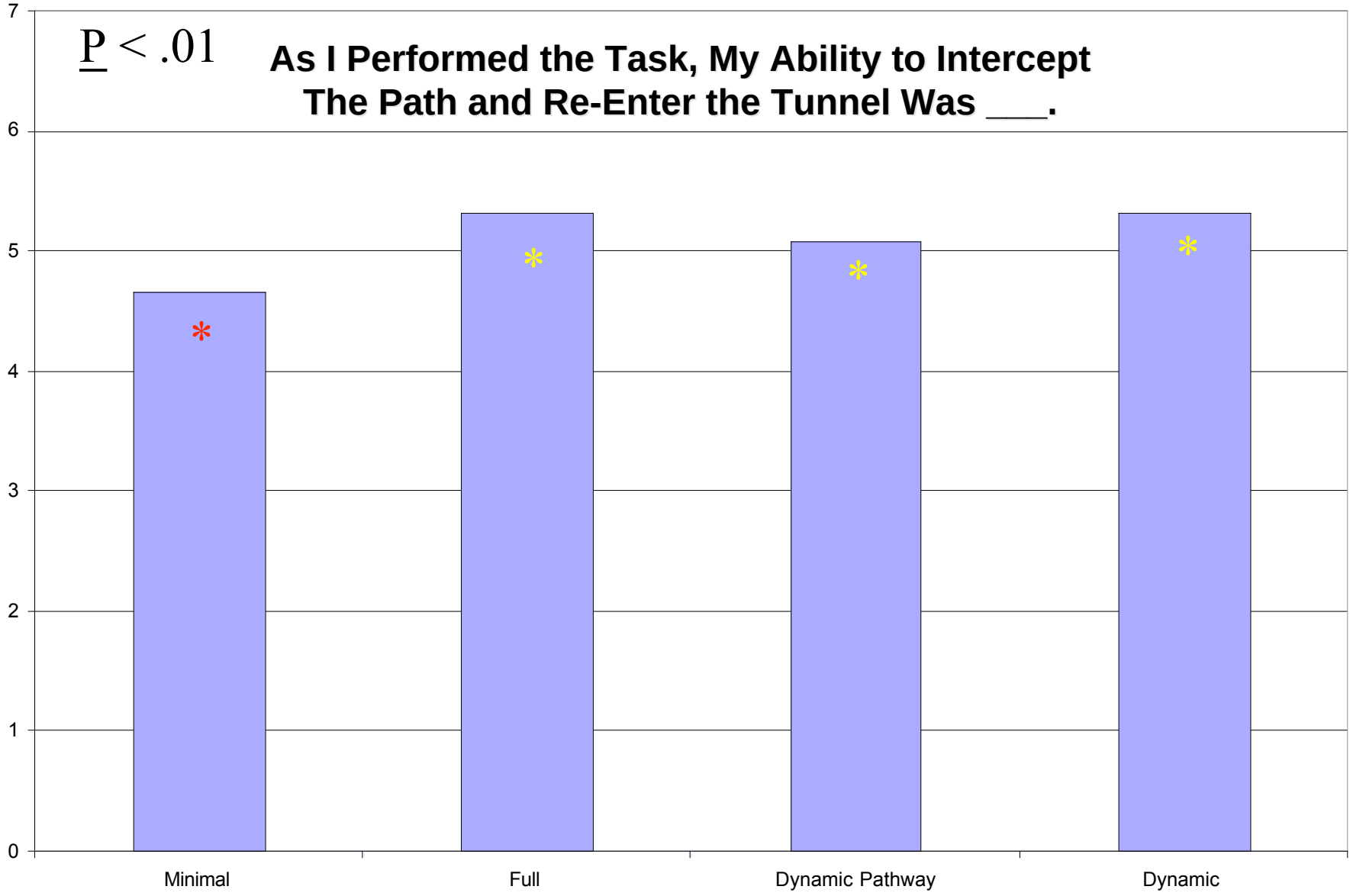
Post-Run Question



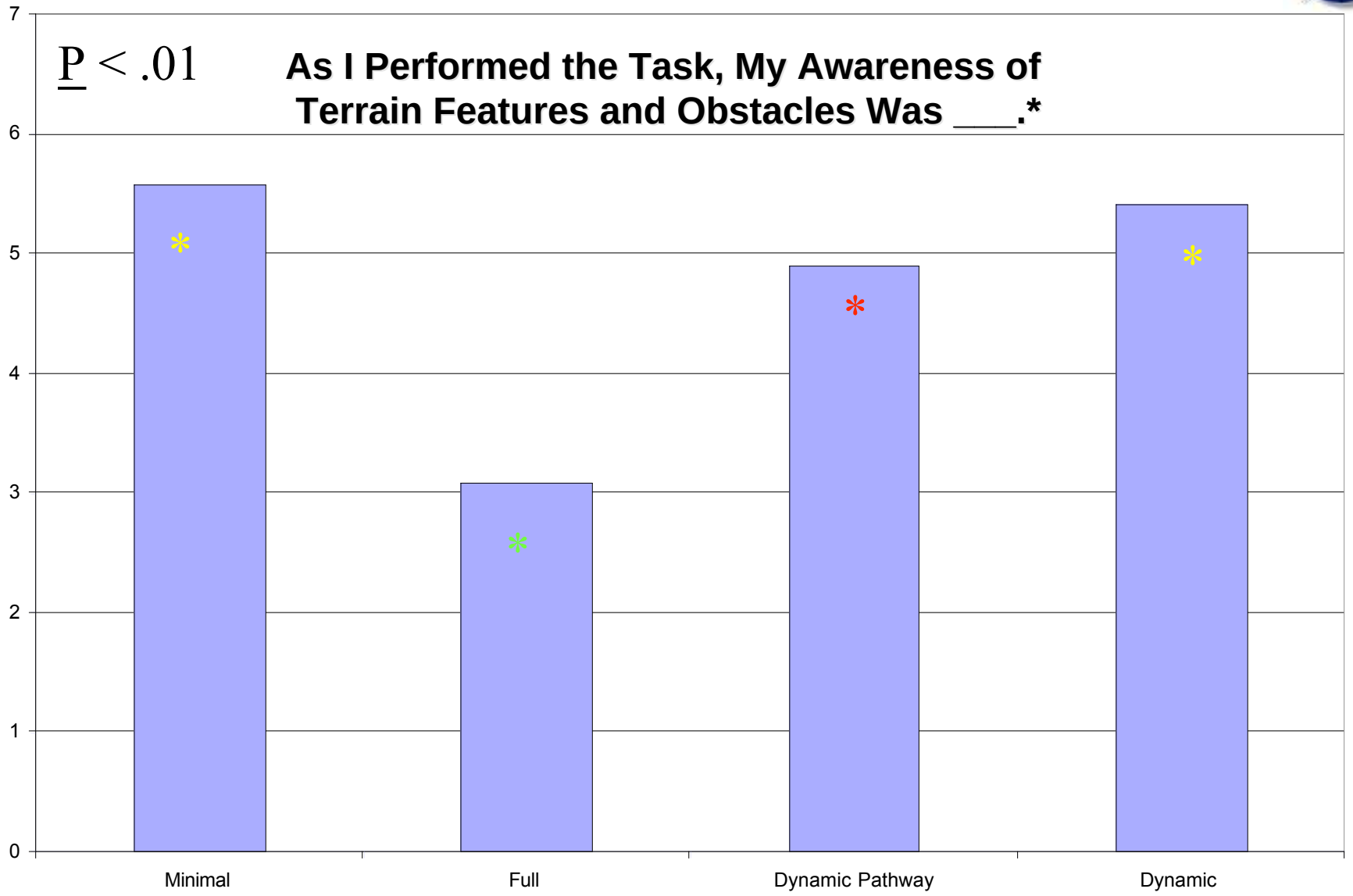
Post-Run Question



Post-Run Question

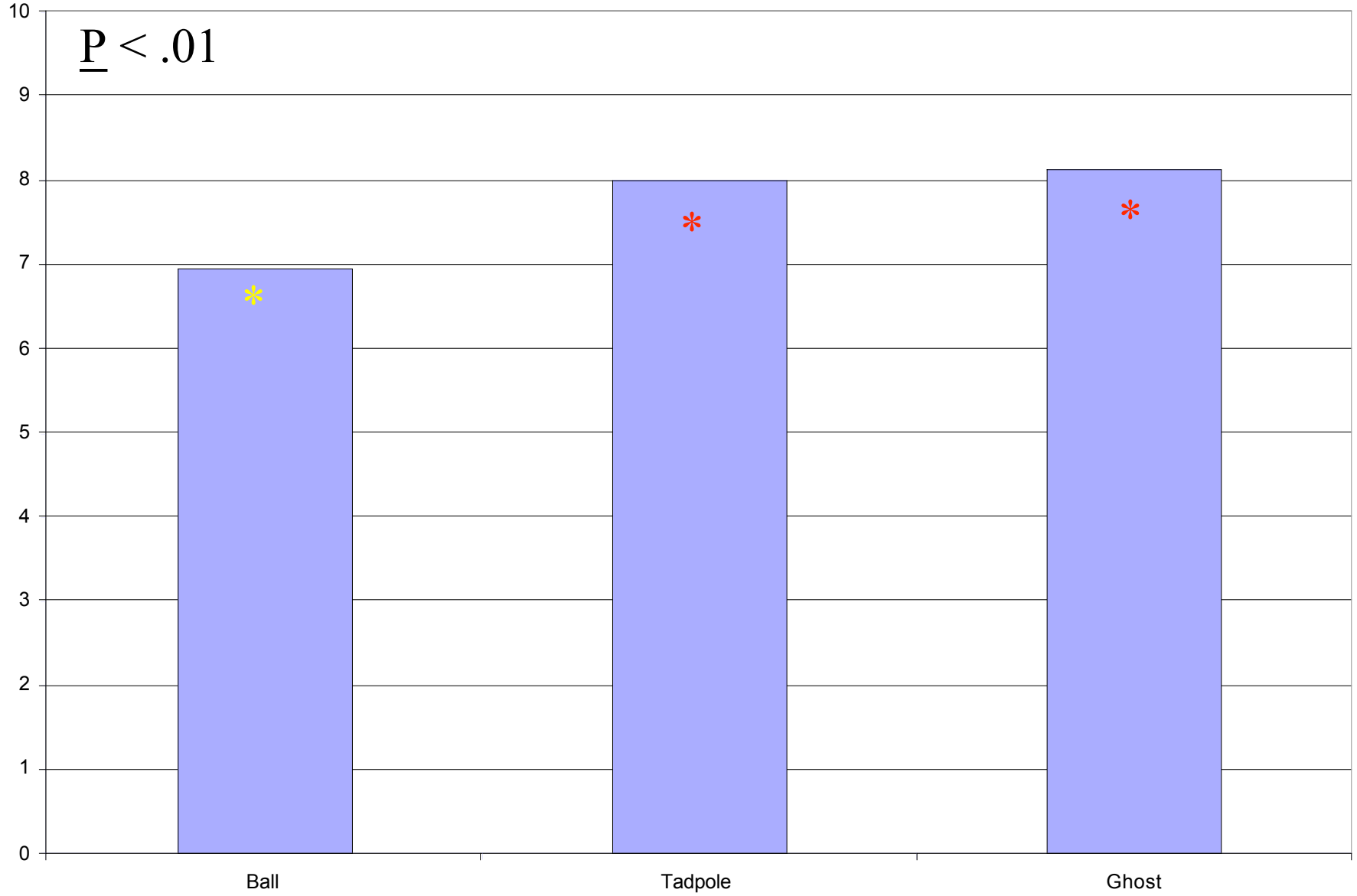


Post-Run Question

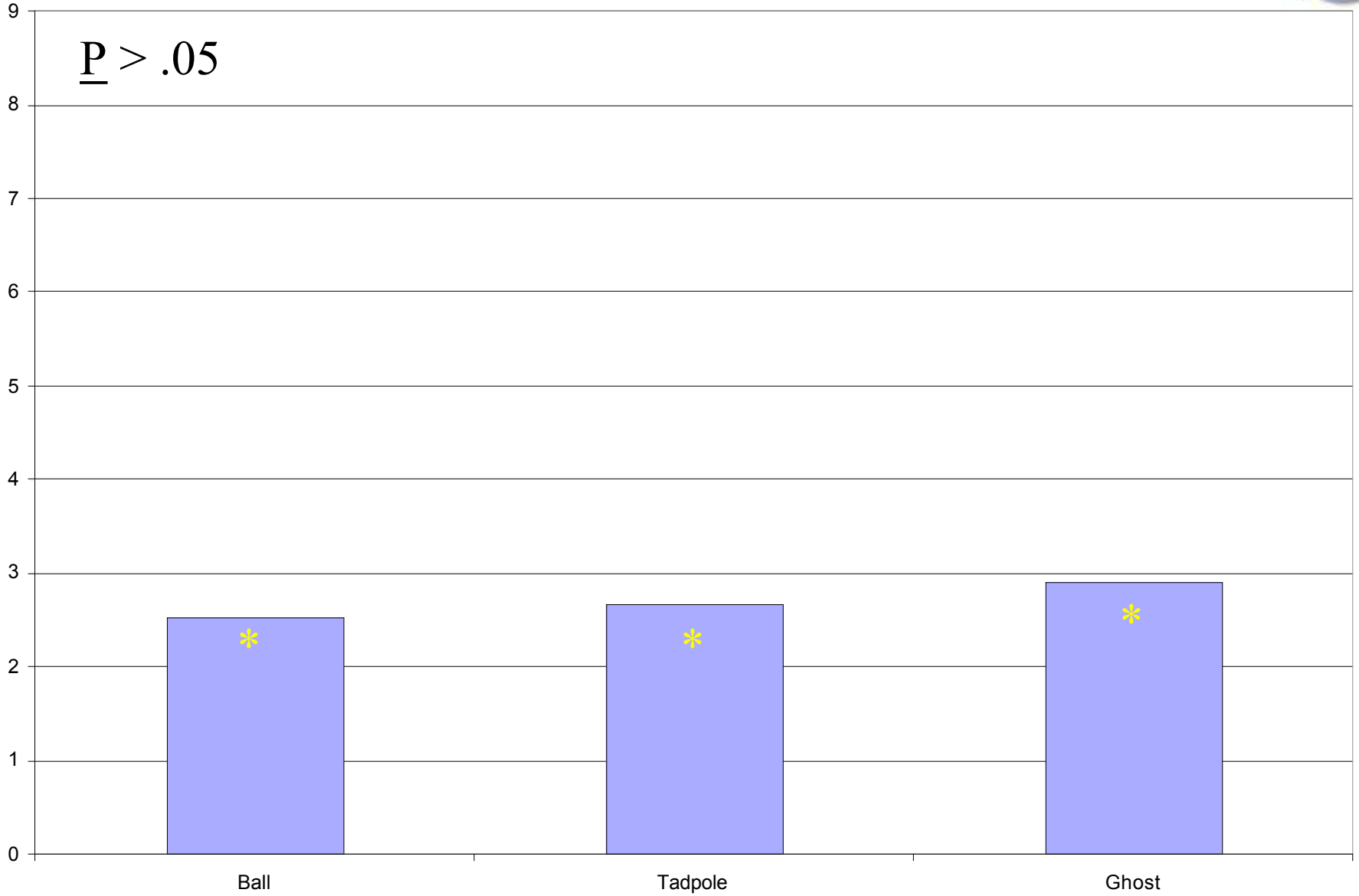


* Pilots were briefed that question concerned clutter versus information

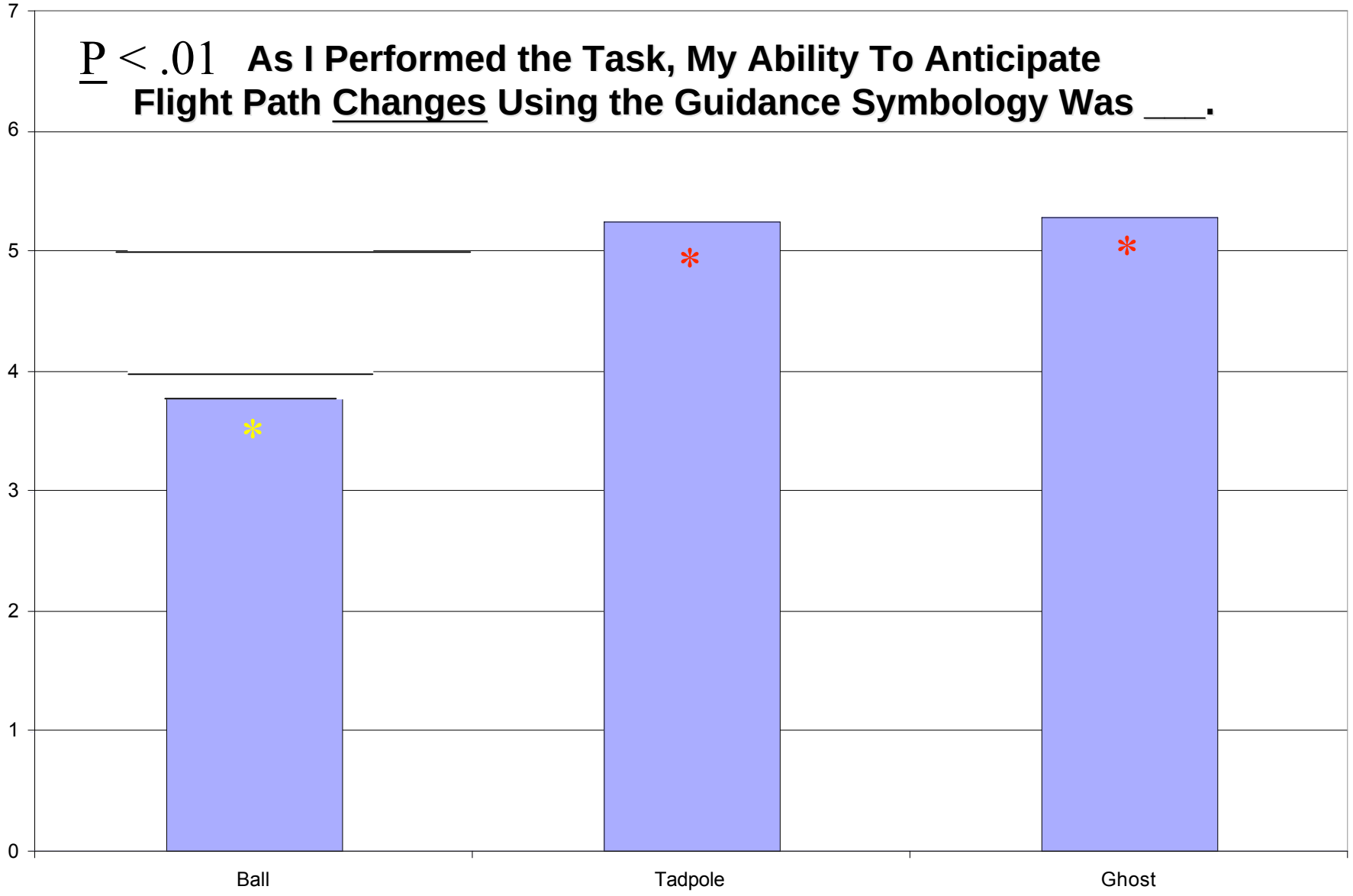
SART Ratings for Guidance Concepts



Workload Ratings for Guidance Concepts



Post-Run Question



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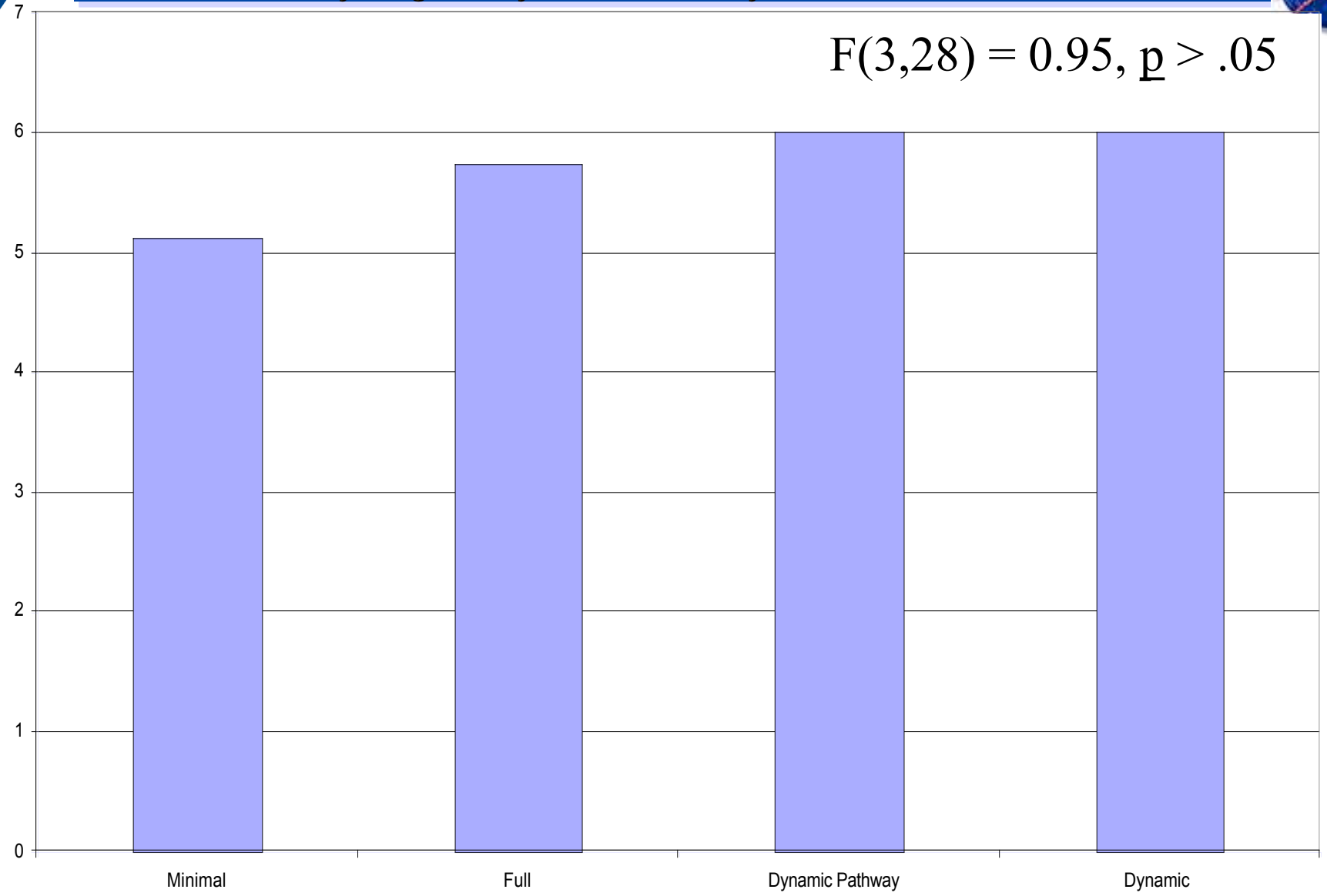
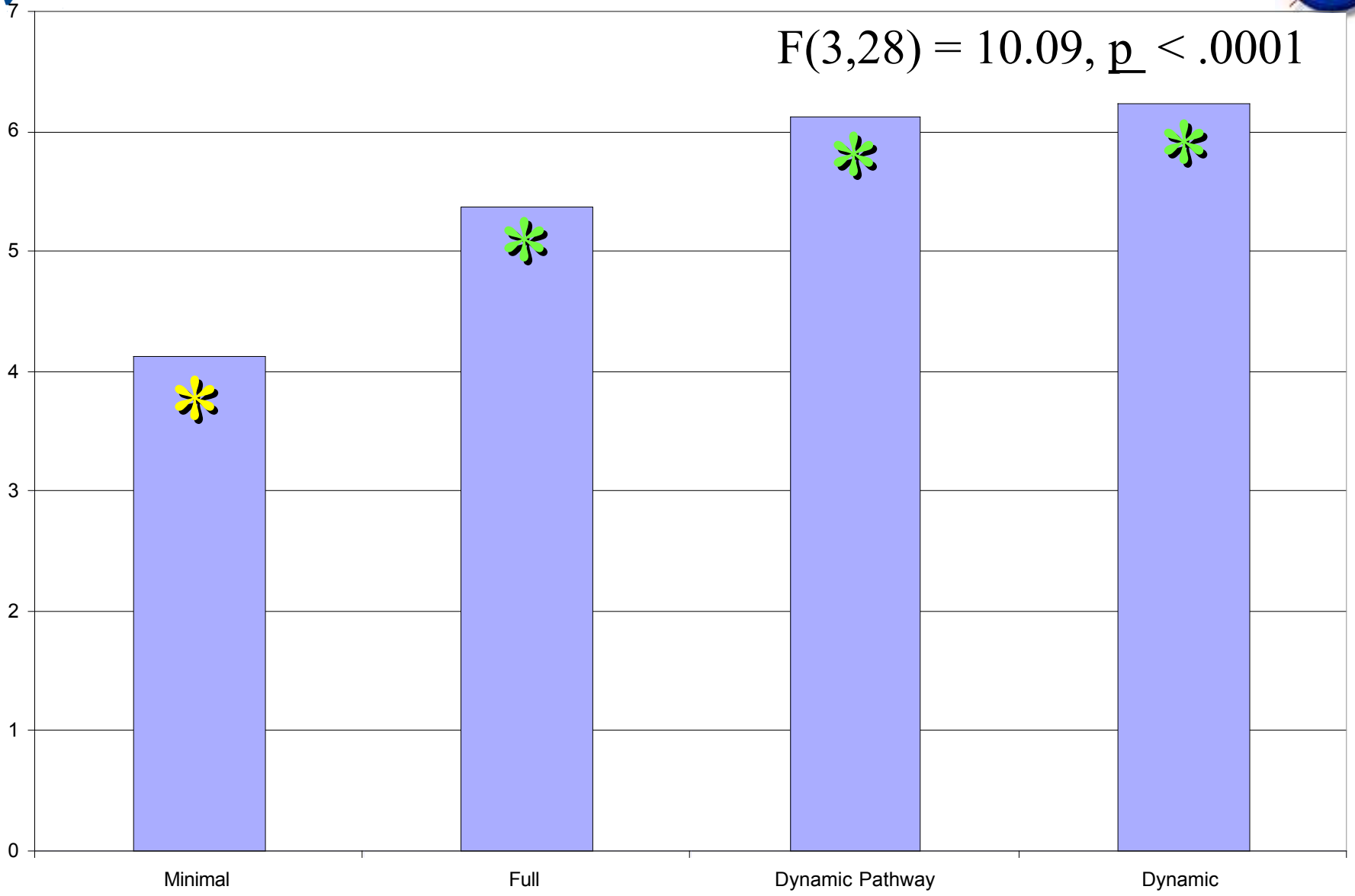
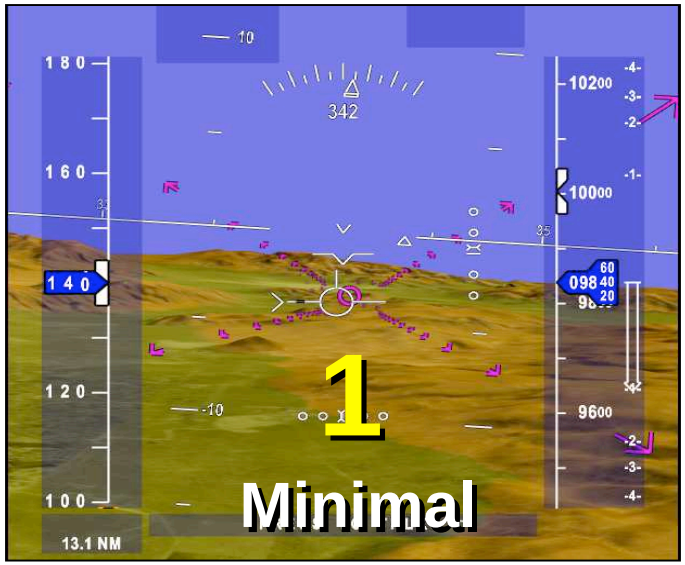
Semi-Structured Interview Results

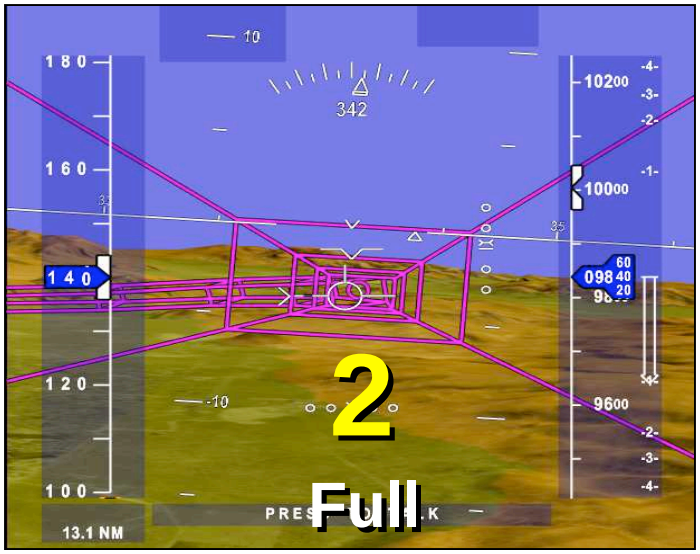
Effectiveness During Straight Path Segments



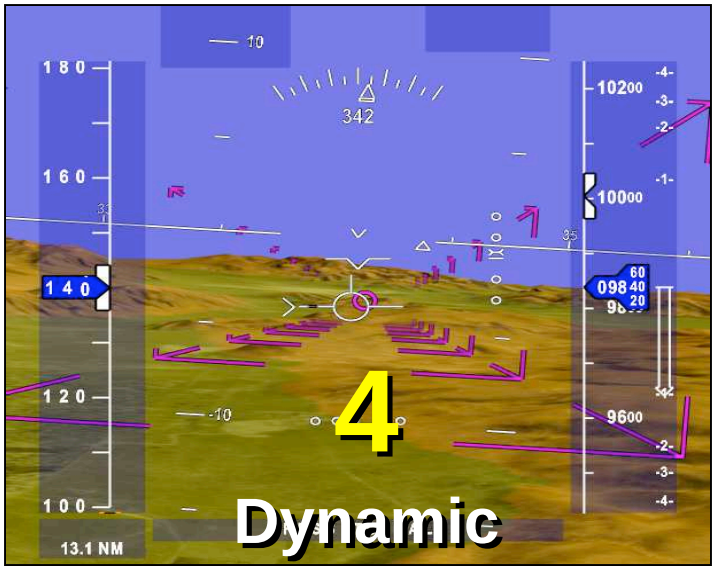
Effectiveness During Curved Path Segments

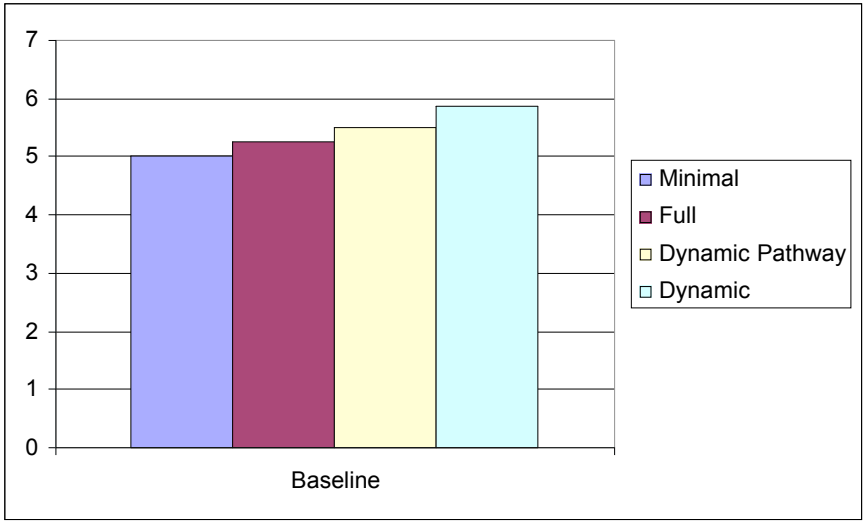


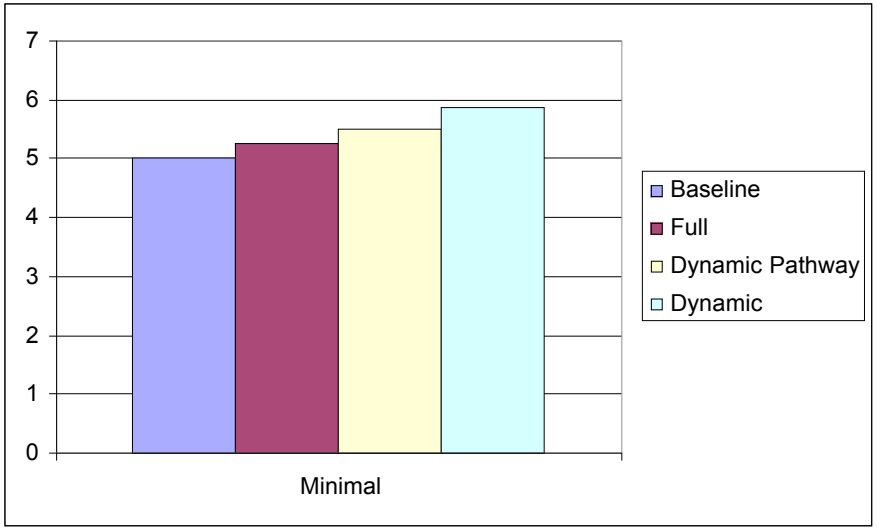




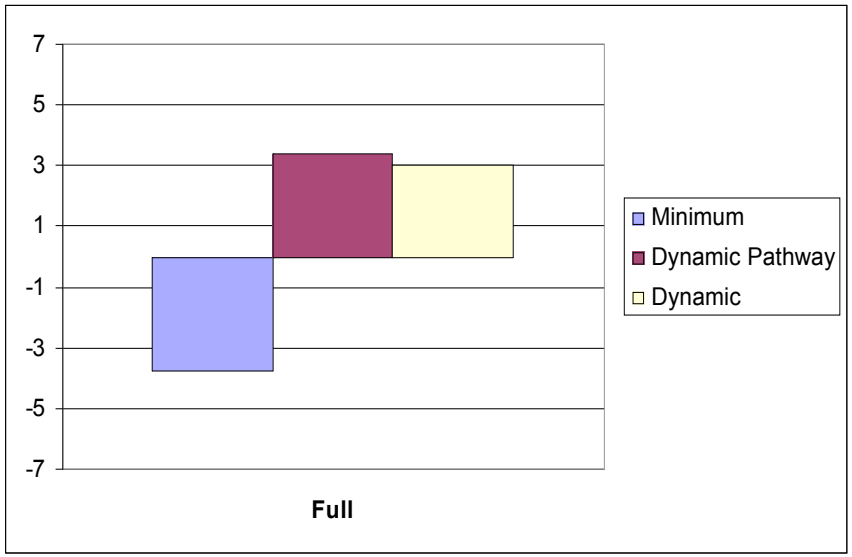
Overall Rank Ordering of Tunnels

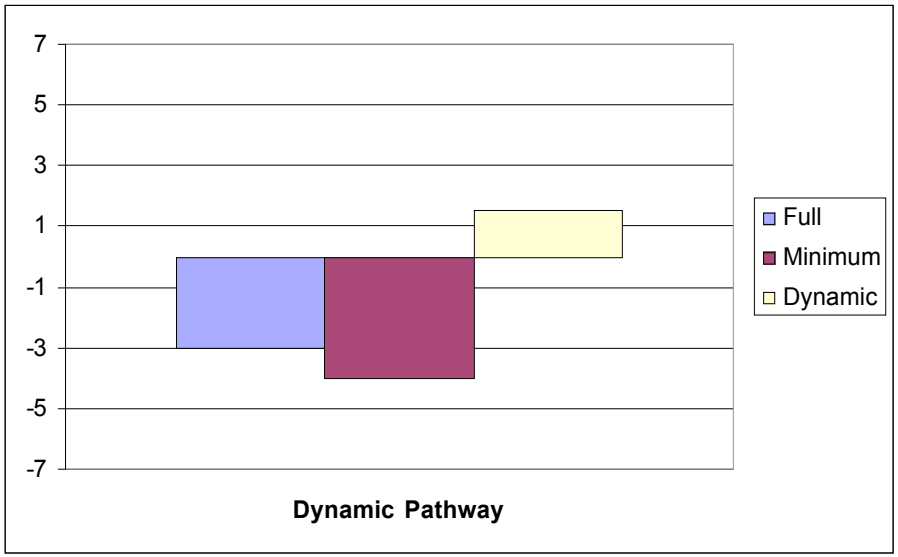




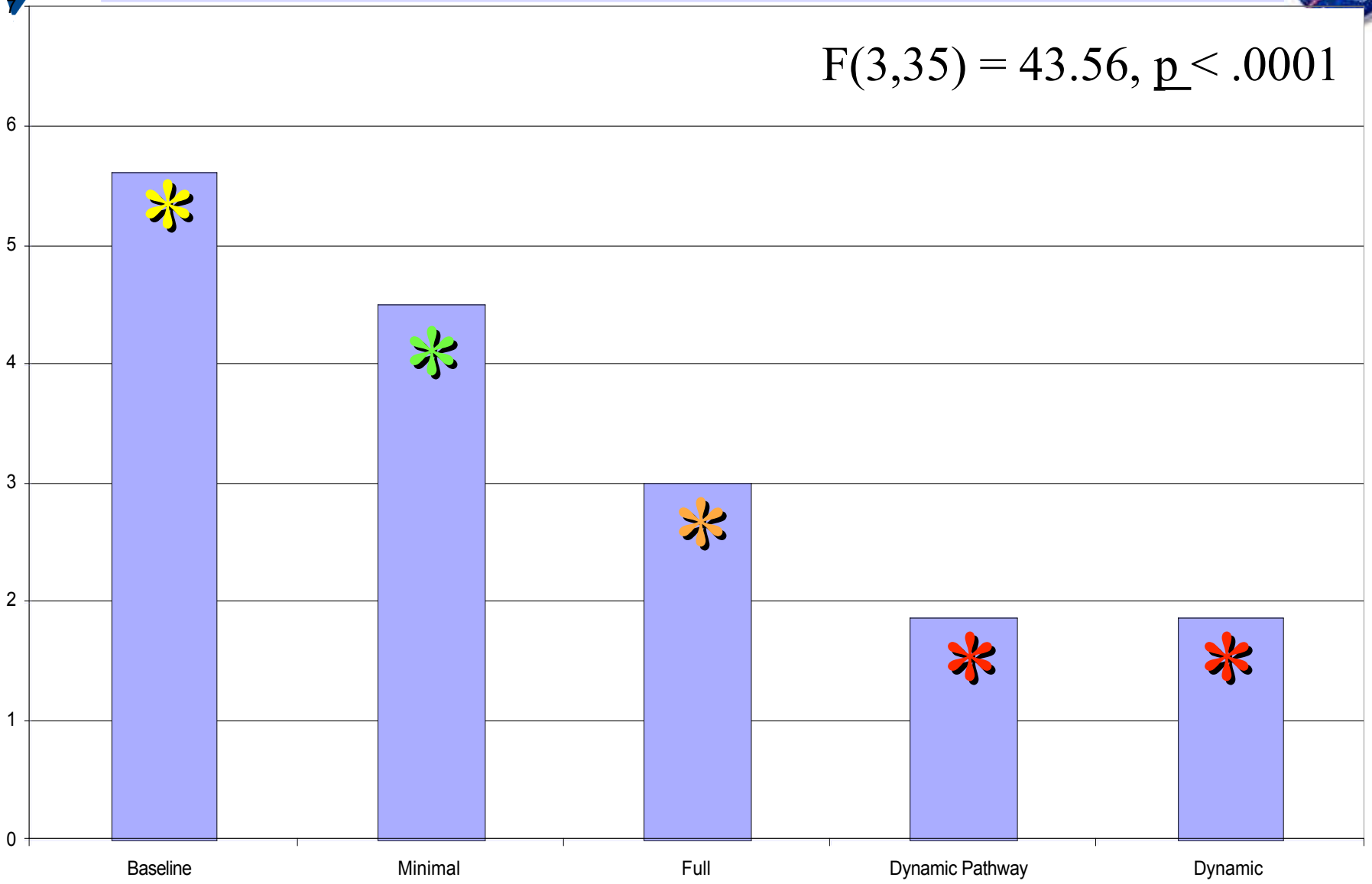


Relative Difference in Situation Awareness Across Concepts

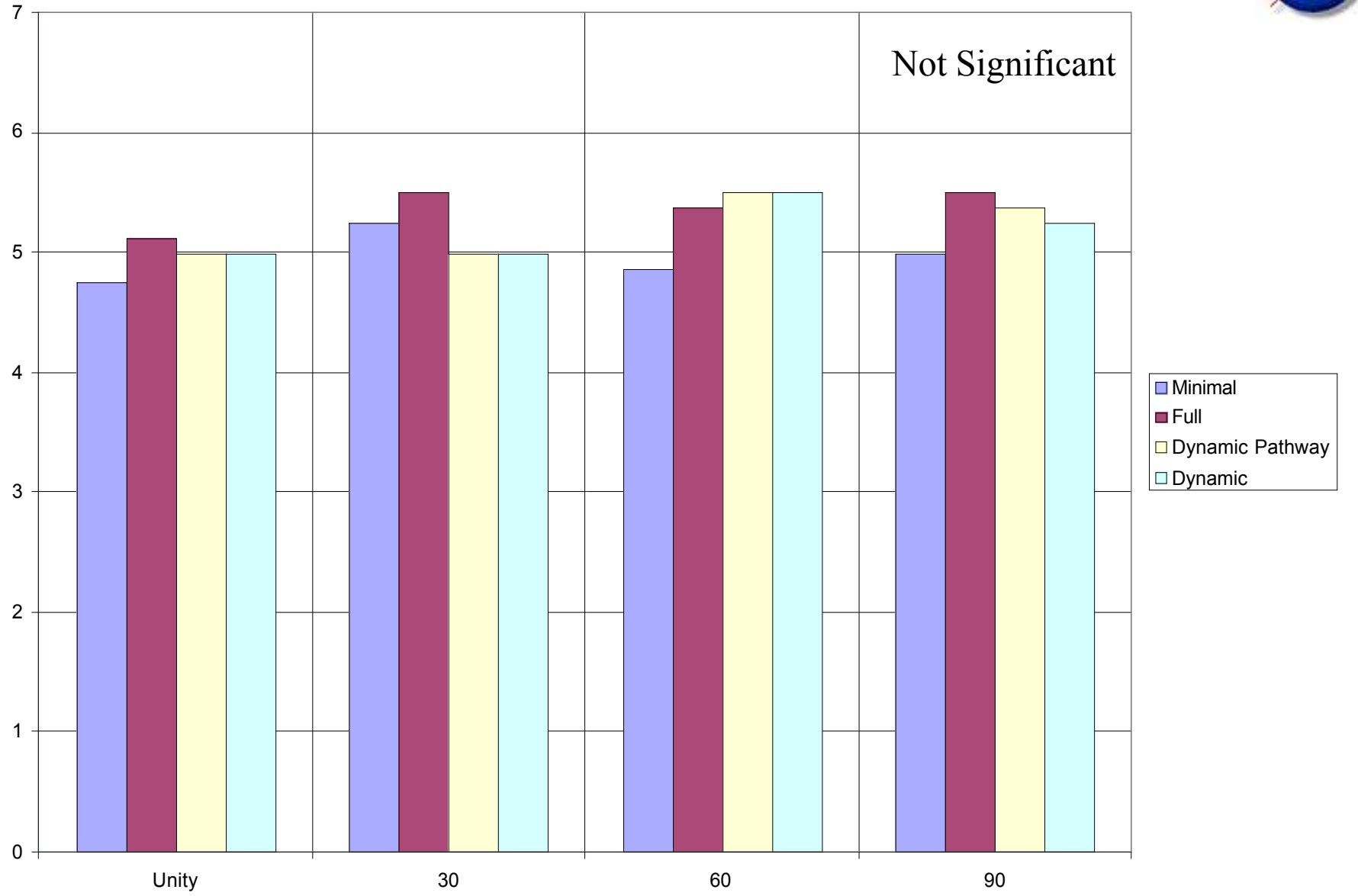




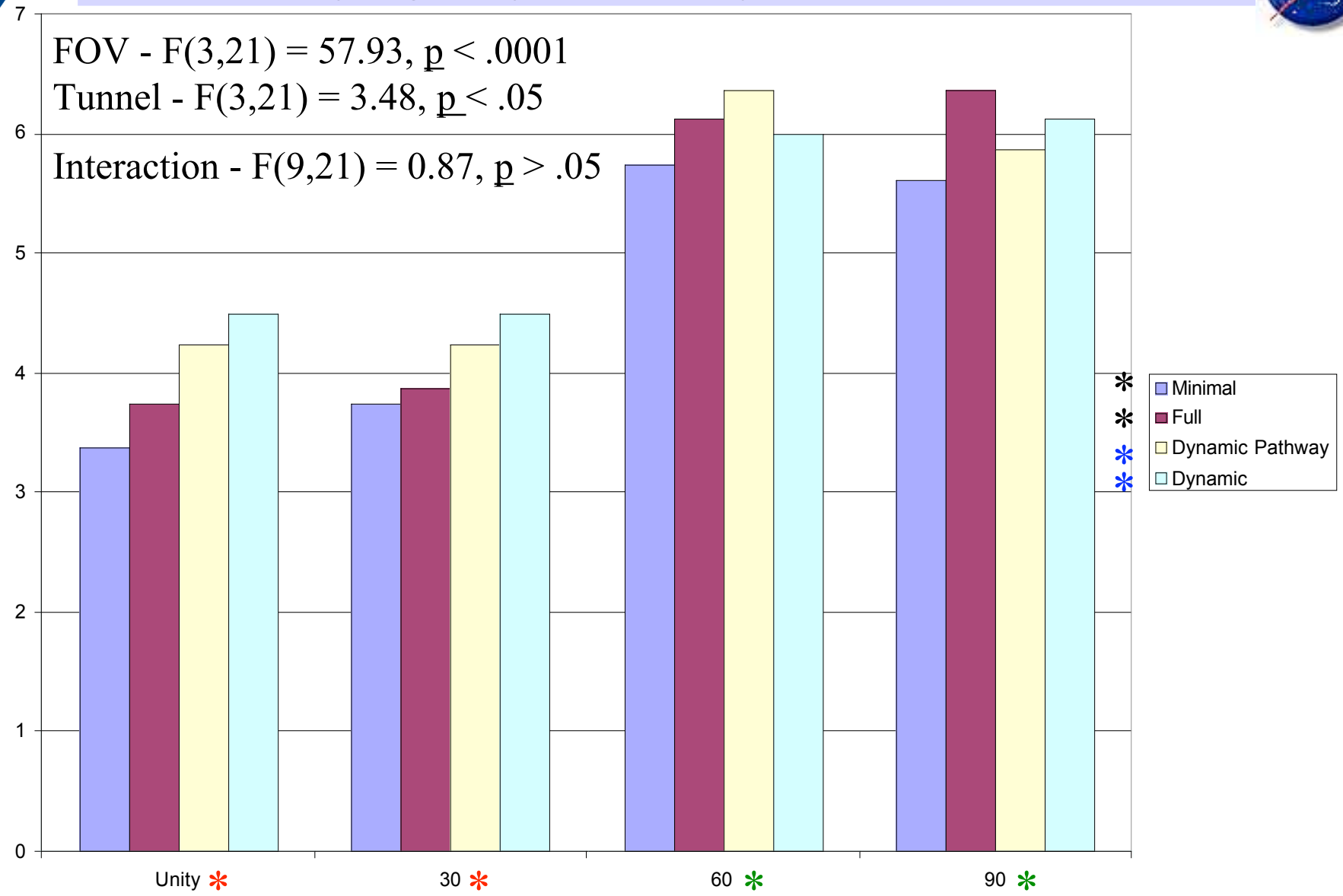
Workload Experienced During "Cut-The-Corner"



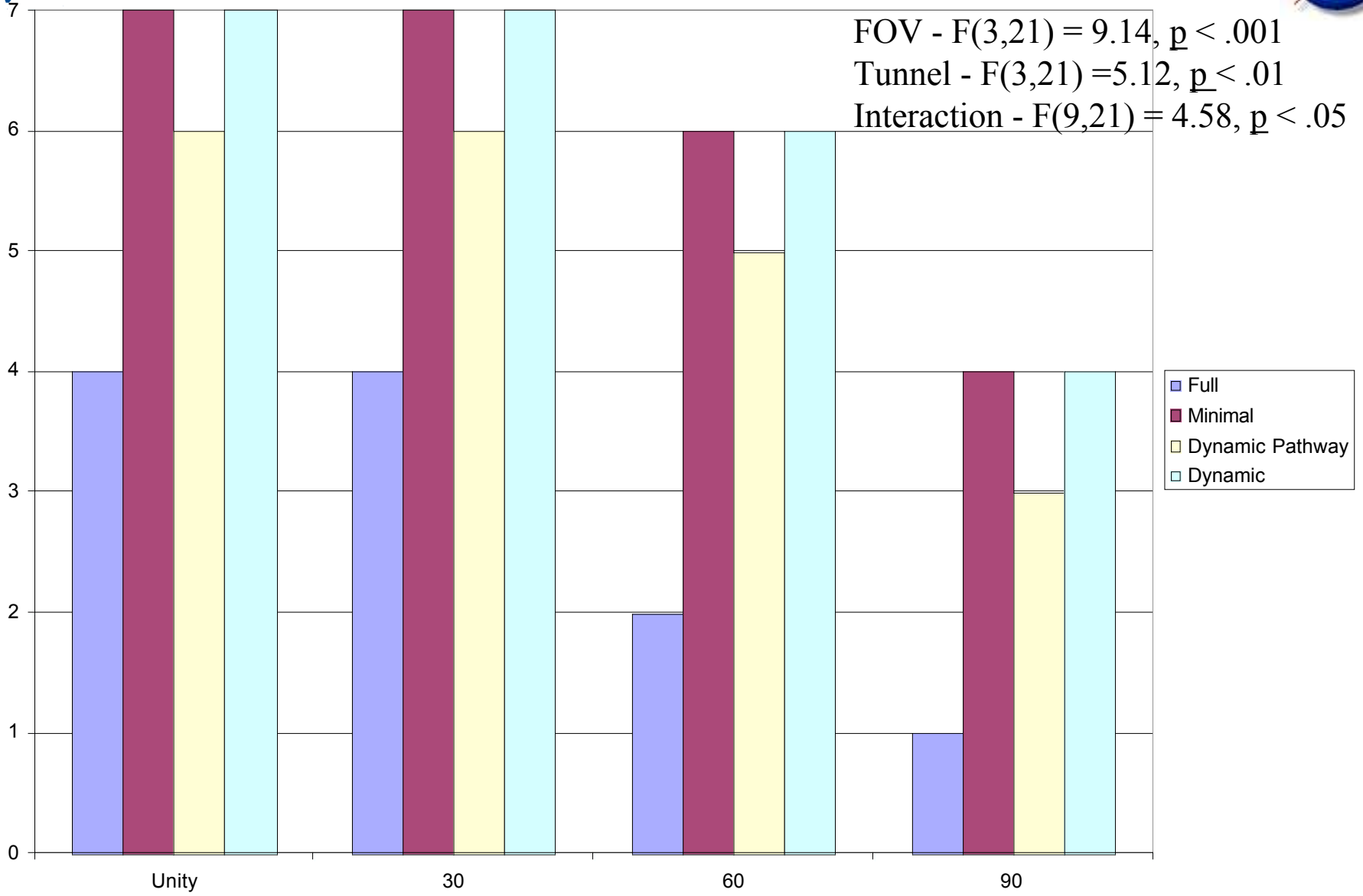
Effectiveness of FOV During Straight Segments



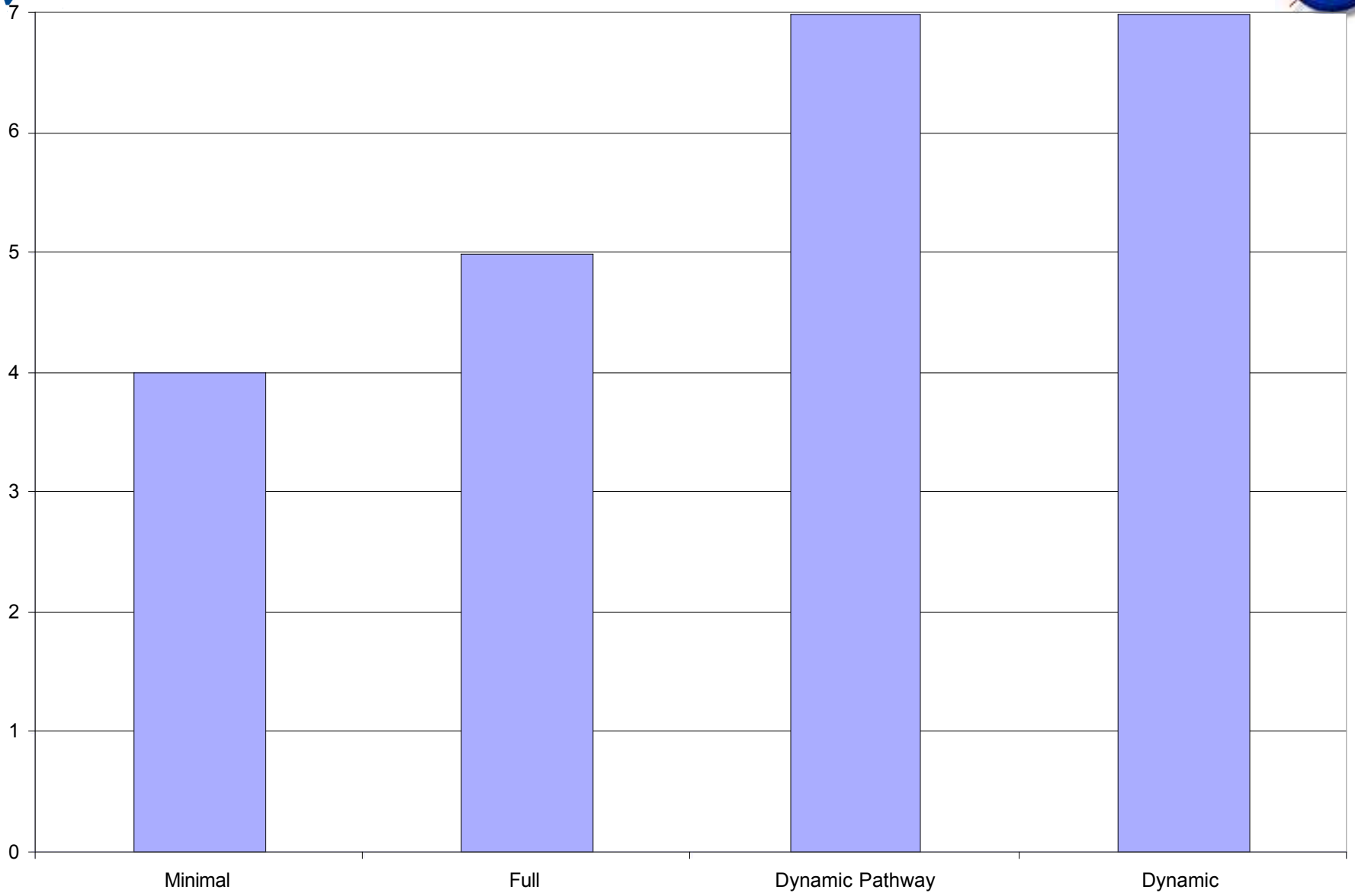
Effectiveness of FOV During Curved Segments



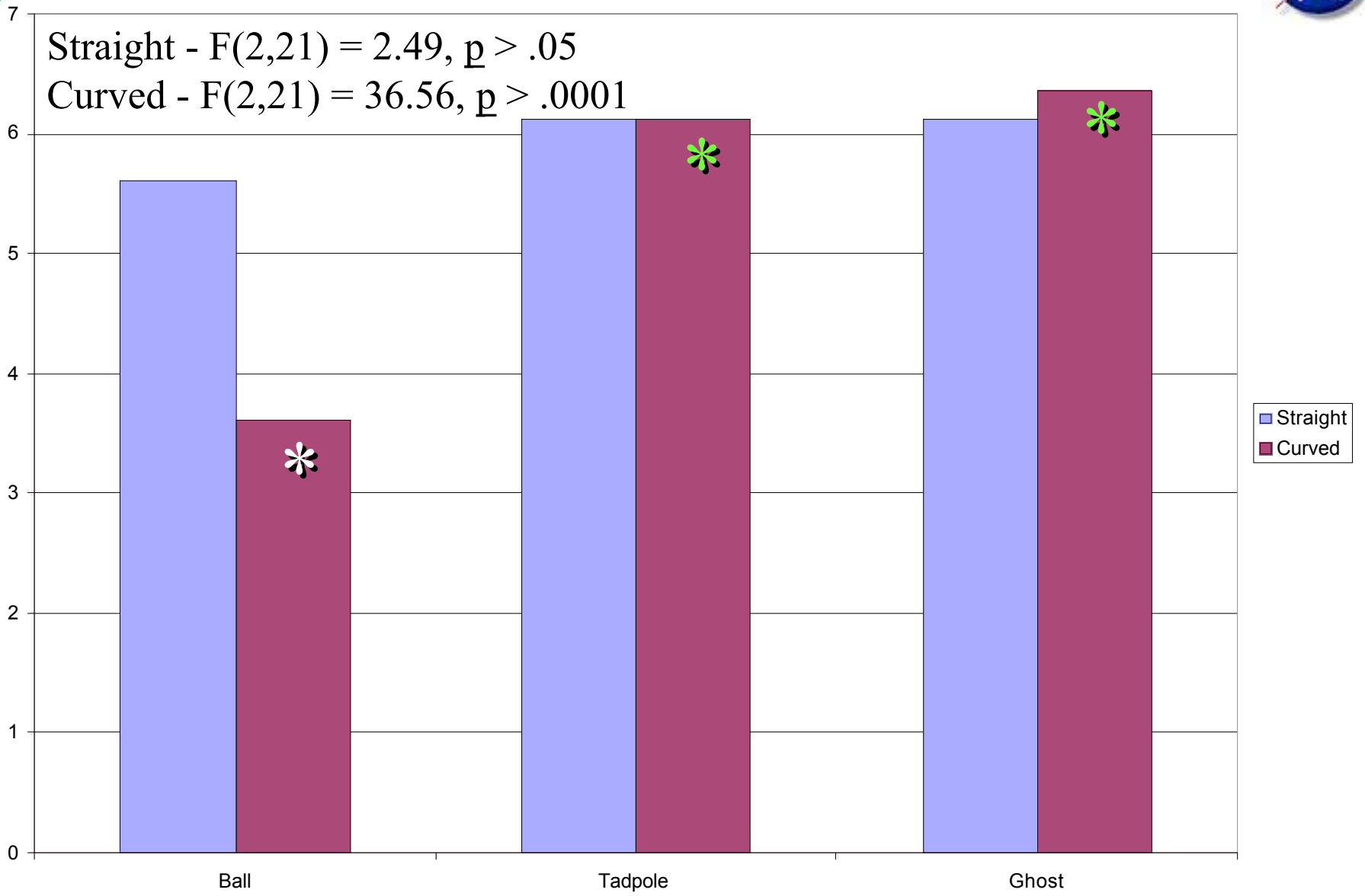
Effectiveness of FOV During Final Approach



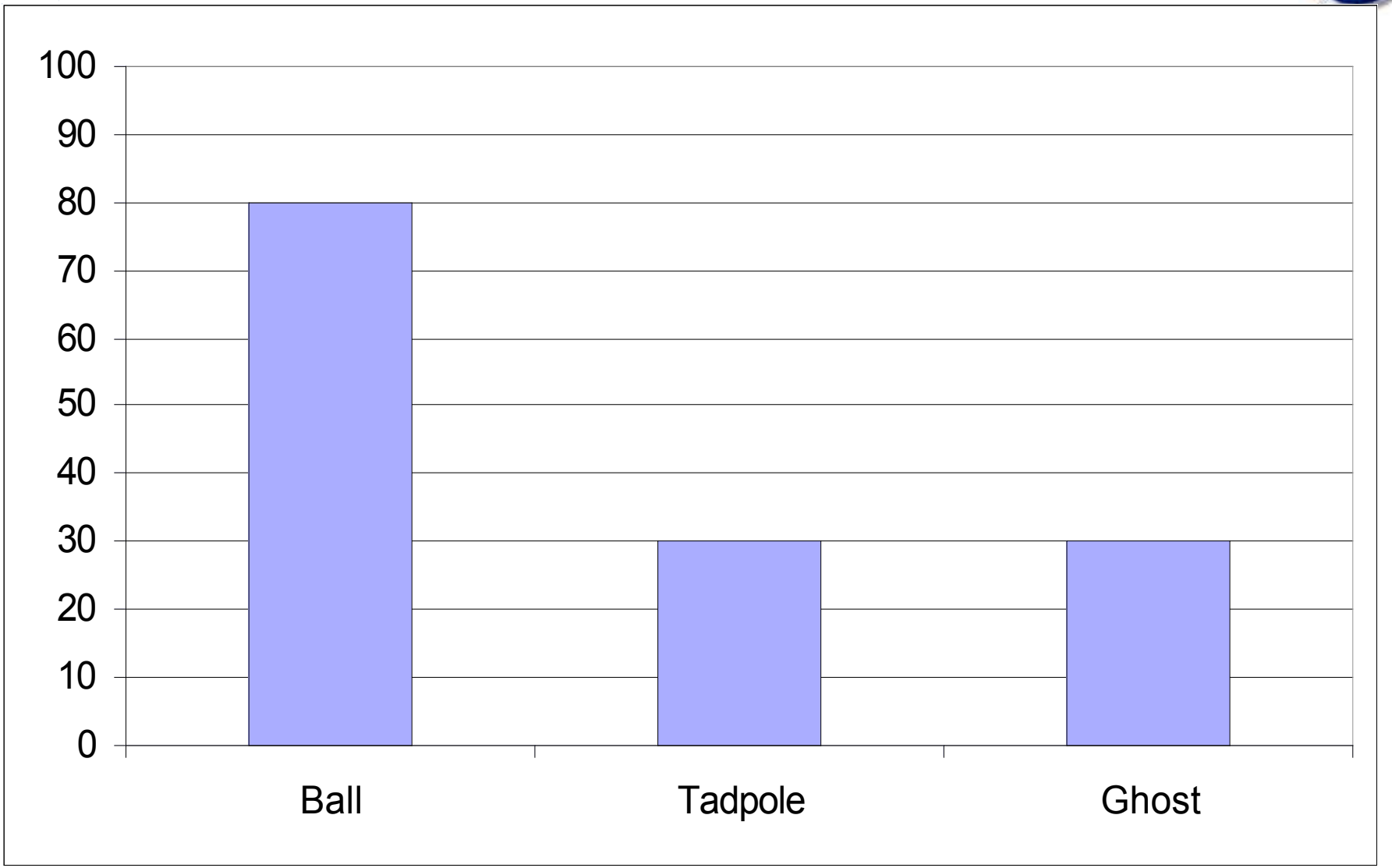
Effectiveness of Tunnel To Re-Enter Tunnel



Effectiveness of Guidance Symbology



% SA Enhancement Provided by Tunnel



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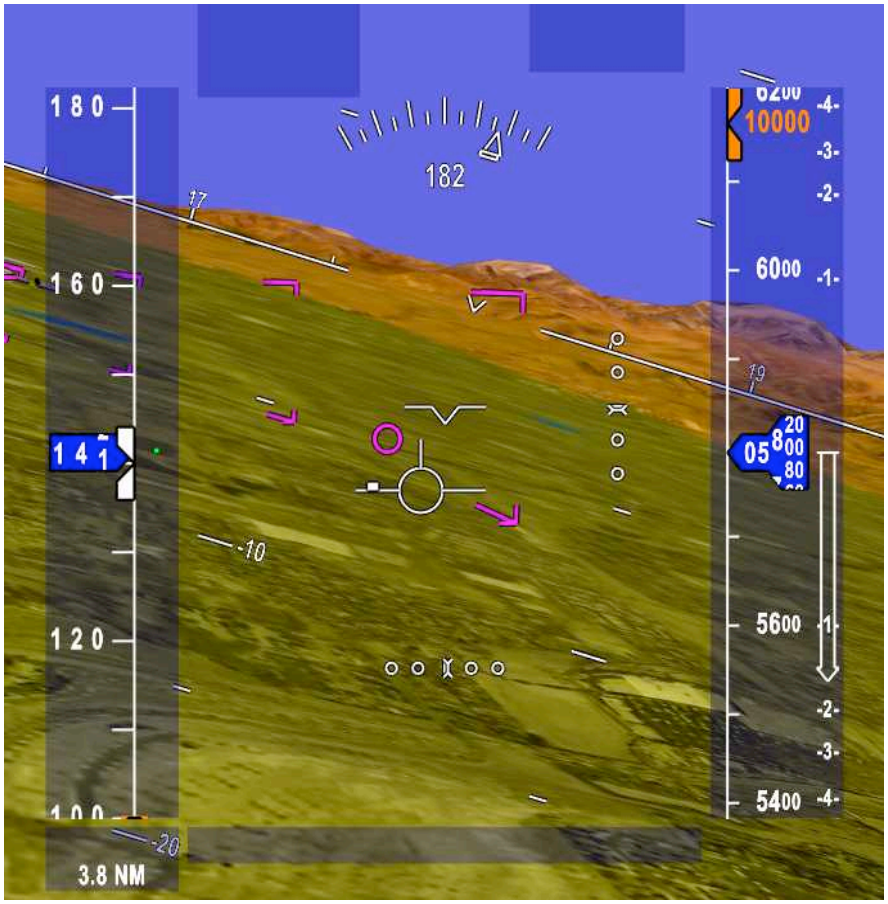
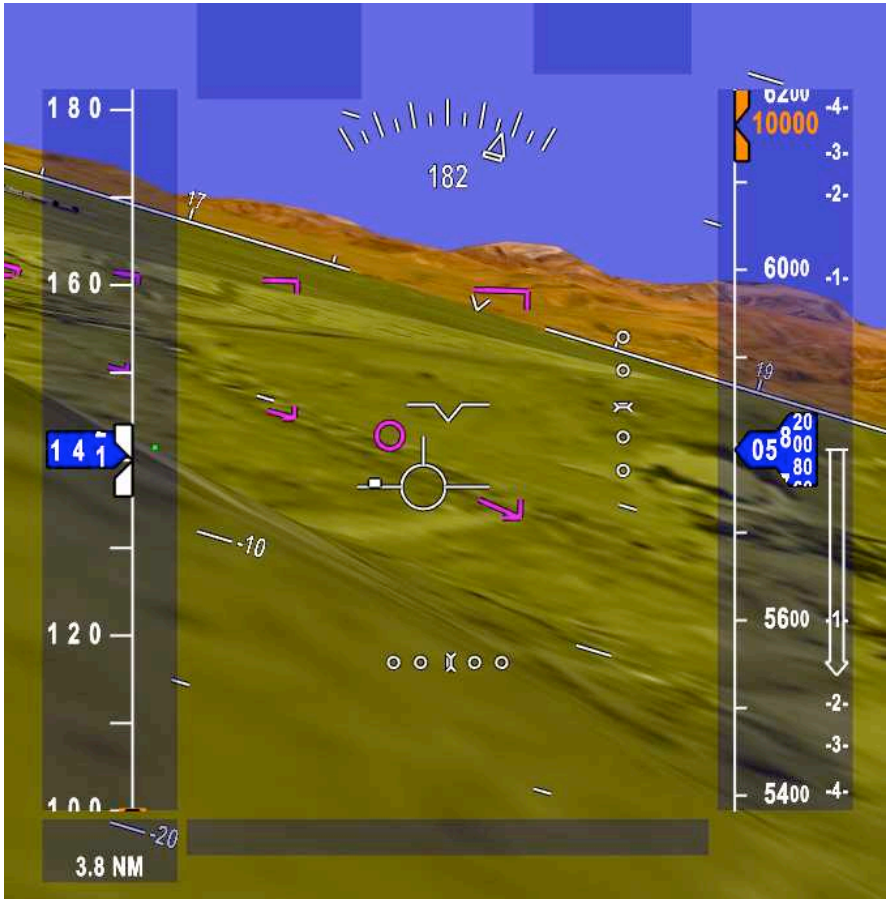
Rare Event Results

Database Error Rare Event



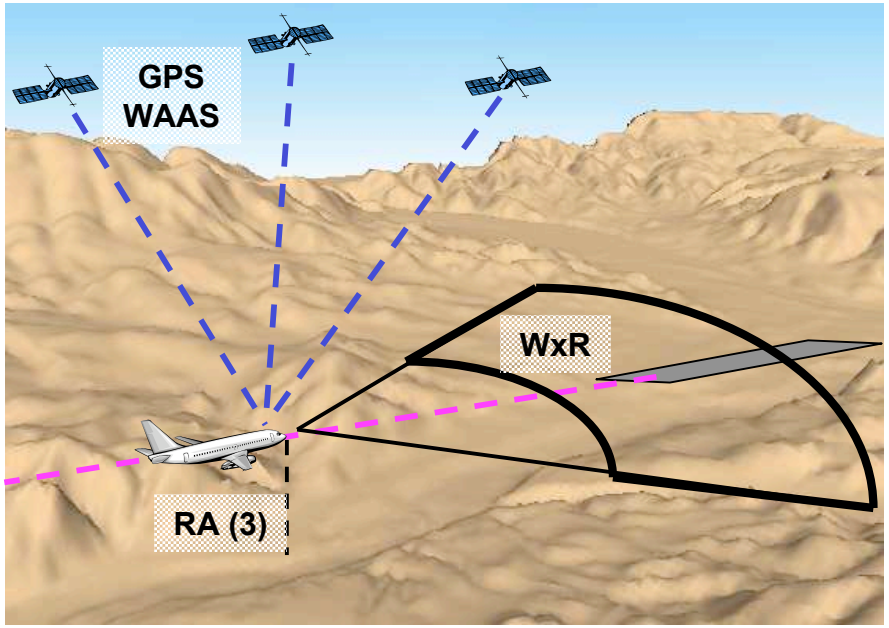
Nominal Run



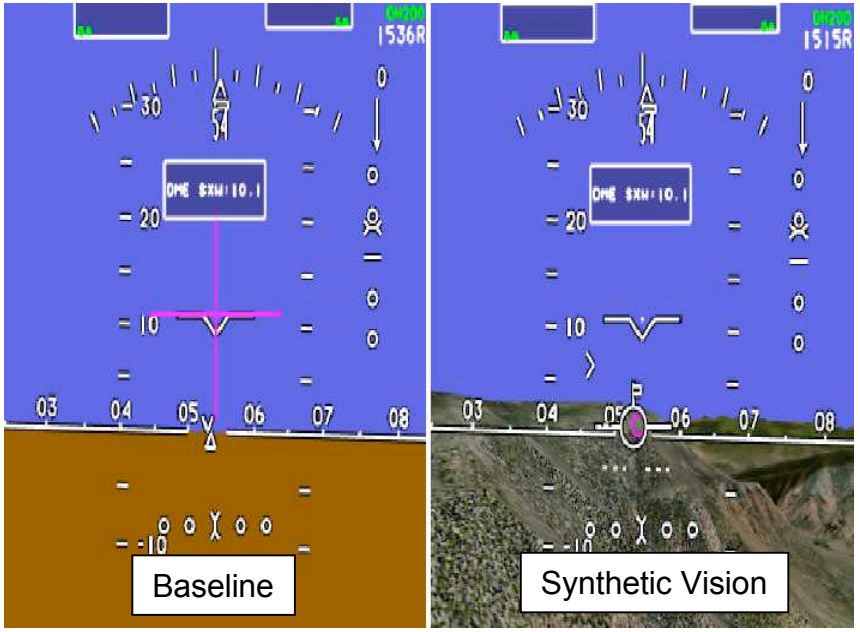
Rare Event Run

Rare Event Results

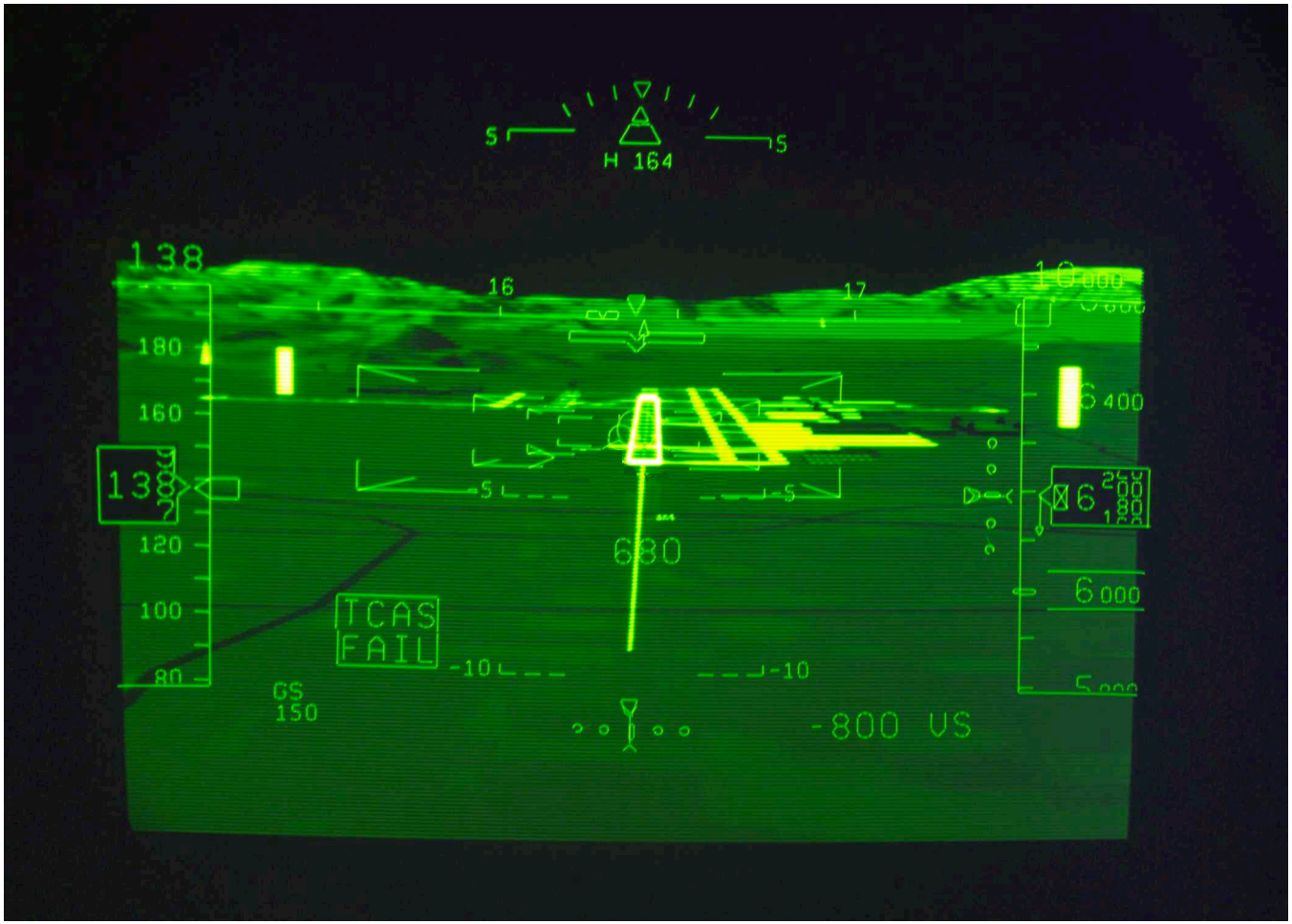
- 0% of pilots noticed the anomaly in time with both the Full and Minimal tunnel concepts
- 100% of pilots noticed the anomaly in time with both the dynamic pathway and dynamic crow's feet tunnel concepts



Database Integrity Monitoring



CFIT Experiment

Head-Up Display Tunnel Experiment (HINSITE)

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